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FEBRUARY 1957

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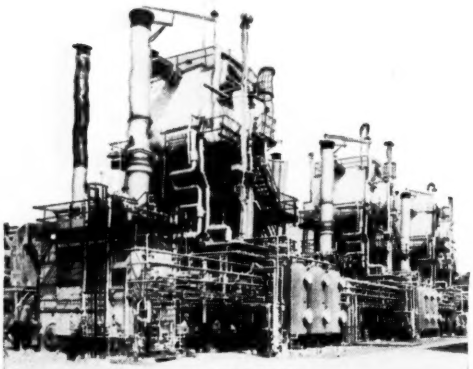

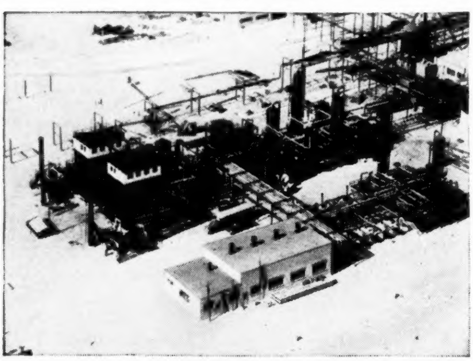

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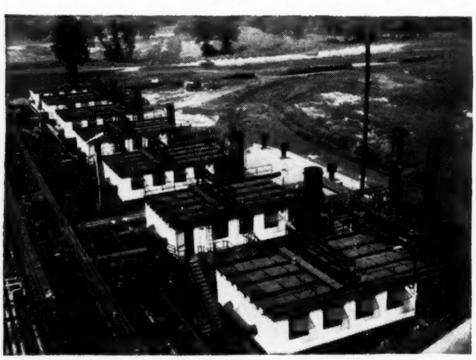

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FEBRUARY 1957

JOHN R. CALLAHAM, Editor-in-Chief

Write More in Less Time

Most engineers do not find it easy to write. For this reason, they're prone to shy away from writing for publication or, when they do undertake it, to "sweat it out" the slow, hard way.

We've found it's quite common for an author to spend only a third of his time assembling data, then two-thirds "composing" the article.

That isn't necessary. All you have to do is to get in touch with us early —the earlier the better. We can then pass along tips that'll save 50% or more of your time (this often makes it easier to get your company's OK). For instances:

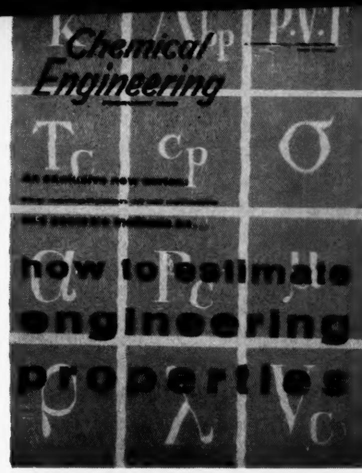
Most important thing to remember: We're interested chiefly in the subject, your treatment of it, its factual content, interpretive accuracy, practical value, breadth of interest to CE's 42,200 subscribers.

You don't have to waste a lot of your time on the niceties of style or abbreviations, nor on mechanical aspects of the manuscript. We'll take care of these.

You don't even have to prepare ink or finished drawings. Just make them legible, accurate and easy to understand—freehand, pencil or ink. Our art department will do the rest.

Like most editors, we reserve the right to make changes that are necessary for conformity to our style, organization and space requirements. If we have questions we'll get in touch with you. If we make major changes we'll ask for your approval.

By working together like this, your part in preparing an article need not be a time-consuming chore.



GUIDED TOUR

To chemical engineers everywhere: Meet a modern concept

For the first time, chemical engineers will have a complete and systematic compilation of methods available for estimating physical properties. Our new series uses the modern concept of design correlations and shows how to calculate reliable values from basic fundamentals. (p. 235)

Beautiful inconsistency

Even though your units are all mixed up, you'll come out with the right values of Reynolds number when you use these new tables. Try them on your next fluid-flow problem and see how they work. (p. 243)

Dramatic process improvement

How an old batch evaporator was revamped by automatic control. Key to suc-

GUIDED TOUR

cess was the use of boiling-point rise to measure product concentration. Output now is continuous and up 10%. (p. 248)

How to tame acetylene

How to tackle the decomposition hazard of compressed acetylene. How to tell the difference between safe and dangerous situations. How your design can avoid trouble in case acetylene is ignited. (p. 250)

Making flowsheets three ways better

Flowsheets can be easier to make and easier to use. Novel proposal promises triple benefits: Equipment indexed for findability; tiers to make take-off easy; simplified connections. (p. 255)

To control any construction schedule

A method perfected by actual use can help you meet your target dates on any kind of construction project. You can now measure on-the-job variables and adjust labor force to finish on time. (p. 261)

To keep pace with development, design, production and technical management in the chemical process industries, more engineers subscribe to CE than to any other magazine in the field. Paid circulation of this issue:

42,197

Chemical

FEBRUARY 1957

Developments in Chemical Engineering

Practice of Chemical Engineering

Engineering

Vol. 64, No. 2

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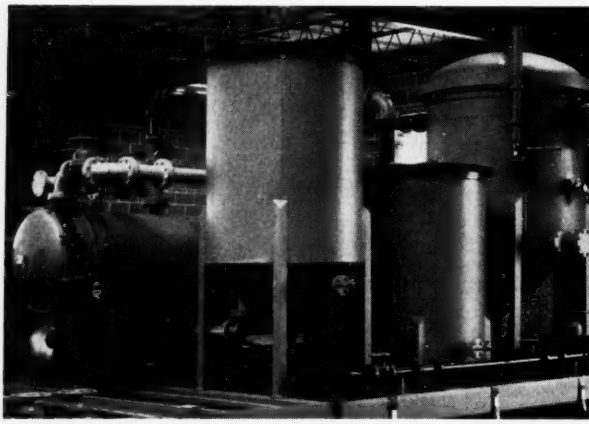
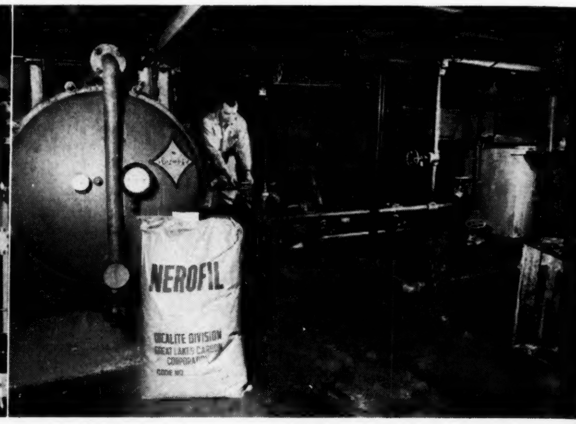
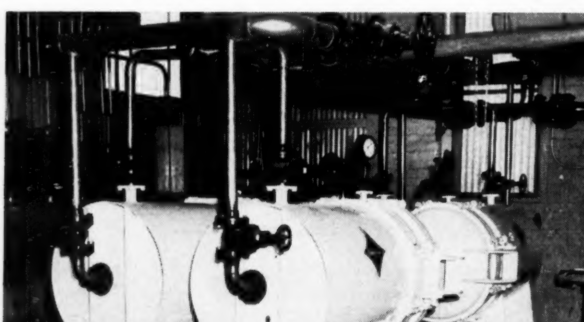
Industrial chemistry?...

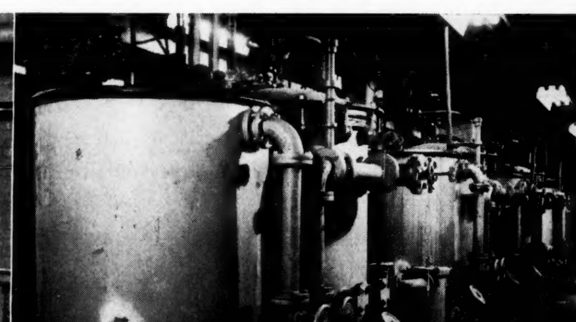




PETROLEUM . . . Certain oil fields that have yielded all oil under normal pressure from underground pools still retain a good deal of usable oil locked in porous rock and shale. By forcing water thru the rock, the oil is driven out and then pumped to the surface. The water used in this process is taken from any available source but must be free of all solids as these would soon fill the pores in the rock formations and the well would cease to produce until the pores were reopened with an acid form of cleaning. This vertical leaf pressure filter was built for heavy-duty rapid purification of water, designed with quick positive cleaning features.

TEXTILES . . . Mercerizing is a process which consists of running cotton thread through a bath consisting of a Caustic Soda solution. This is performed prior to dying and is responsible for its superior luster and strength. These Industrial Horizontal type Filters continually remove all foreign or suspended particles from the Caustic Soda down to 2 microns . . . thus producing a cleaner, finer cotton thread. Cleaning is especially easy. When the filter is open, a truck can be placed under the leaves and a shaking device shakes the cake from the leaves directly into the truck.





FOOD . . . This battery of 4 Tubular Filters is used for final clarification of sugar liquor. Operated two at a time they process 27,000 lbs. in 15 minutes and from 5 to 11 batches can be treated before cleaning. Tubular Filters were recommended by Industrial for economy and convenience in processing various sizes of batches. Each contains 7 perforated tubes lined with filter paper. Cleaning is especially convenient . . . the filter papers are simply taken out and replaced.

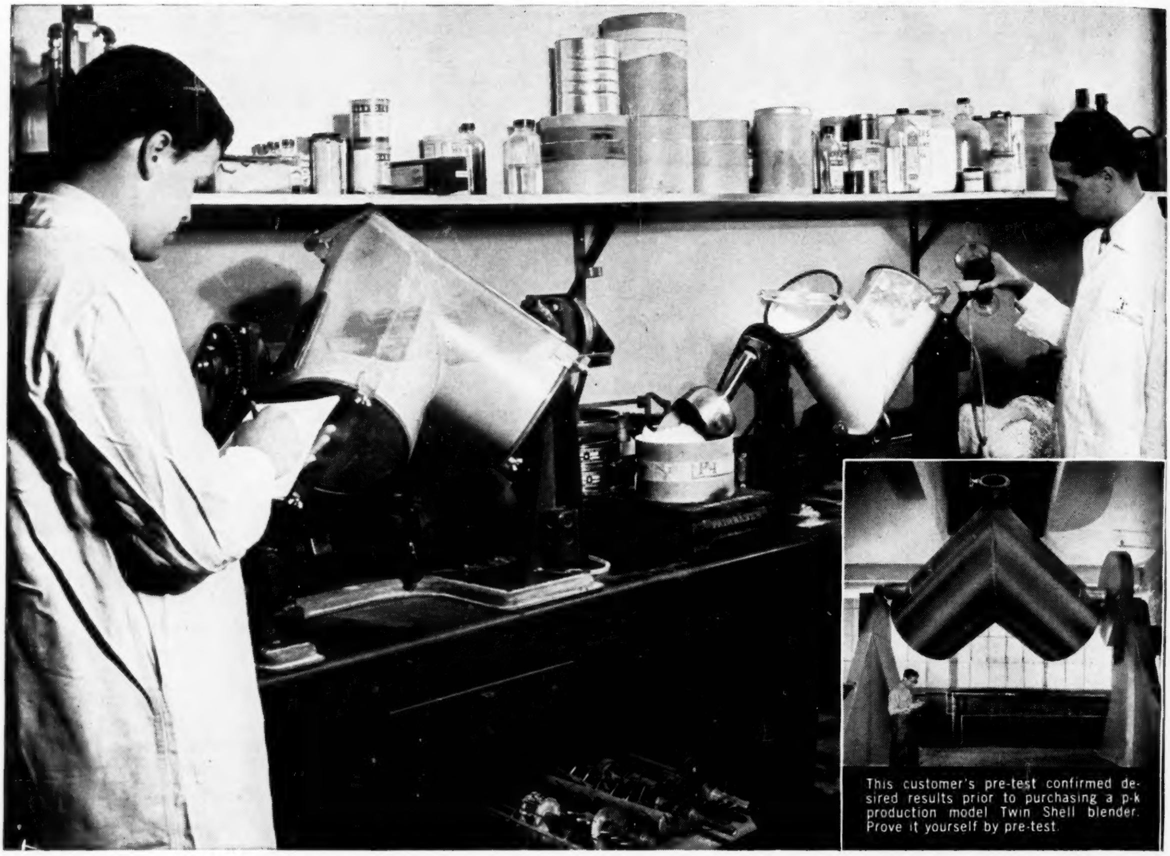
METALS . . . The handling of a hot complex sulfate solution in a large plating installation points up two important Industrial features. These filters are particularly convenient to use in parallel for large jobs . . . each filter can be dropped out for cleaning without interfering with the rest of the units. These filters are rubber-lined for corrosion resistance. Remember . . . properly engineered solution and water filtration equipment is the key to quality production.

Chemical Engineering

Developments

FEBRUARY 1957

Department Index



This customer's pre-test confirmed desired results prior to purchasing a p-k production model Twin Shell blender. Prove it yourself by pre-test.

Chementator

H. T. SHARP

√ **Wide distribution of low-grade uranium ores in the Pacific Northwest will eventually prove more attractive to processors than smaller high-grade deposits now mined, according to mining experts. This portends a drastic shift in processing activities.**

√ **Ultra-fine iron particles have been used by General Electric to make magnets of "super strength." They are expected to lead to significant advances in instrumentation.**

√ **Dow is developing a production process for polyethylene based on modifications of the Ziegler process.**

√ **AEC's Oak Ridge labs has found a new method of reprocessing irradiated fuel elements. Uranium and uranium-zirconium alloys are separated from the waste by leaching with hot mercury, recovered by boiling off the mercury.**

Atomized suspension gaining uses

Atomized suspension, a novel processing technique developed by the Pulp & Paper Research Institute of Canada (*Chem. Eng.*, Nov. 1955, p. 105; Dec. 1955, p. 118), is about to get its first semicommercial trial in a unit built in Scotland by George Scott & Son, Ltd. This installation will process waste liquor from a soda pulping operation.

Other interest has also developed in the technique, which involves pressure-spraying solutions or slurries into the top of a tower and heating the atomized particles by radiation from the hot (1,100-1,500 F.) tower walls. (With no vapor present except that from the heated material, there is no air film around each particle and heat transfer is rapid.)

A group of U. S. and Canadian chemical companies and pulp mills are sponsoring pilot-plant research at the Institute on the simultaneous recovery of ammonia and sulfur dioxide from ammonia-base pulping liquors.

In addition, pickle liquor recovery via atomized suspension is under study by Research Cottrell at Bound Brook, N. J. And an aluminum producer is reported interested in using the method in conjunction with the standard Bayer process. In other pilot work at the Institute, processing time for recovering certain important metal values from aqueous solutions was cut from 7 hr. to 7 sec.

Possibly the first large-scale use of the method will be for sewage disposal. Francis Henken Co., Montreal, will put in a small ($25,000) disposal plant in a Canadian city of some 10,000 population. This installation will be closely watched by government officials and, if successful, the method will be widely used in Canada for this purpose.

Process reclaims Titanium from scrap

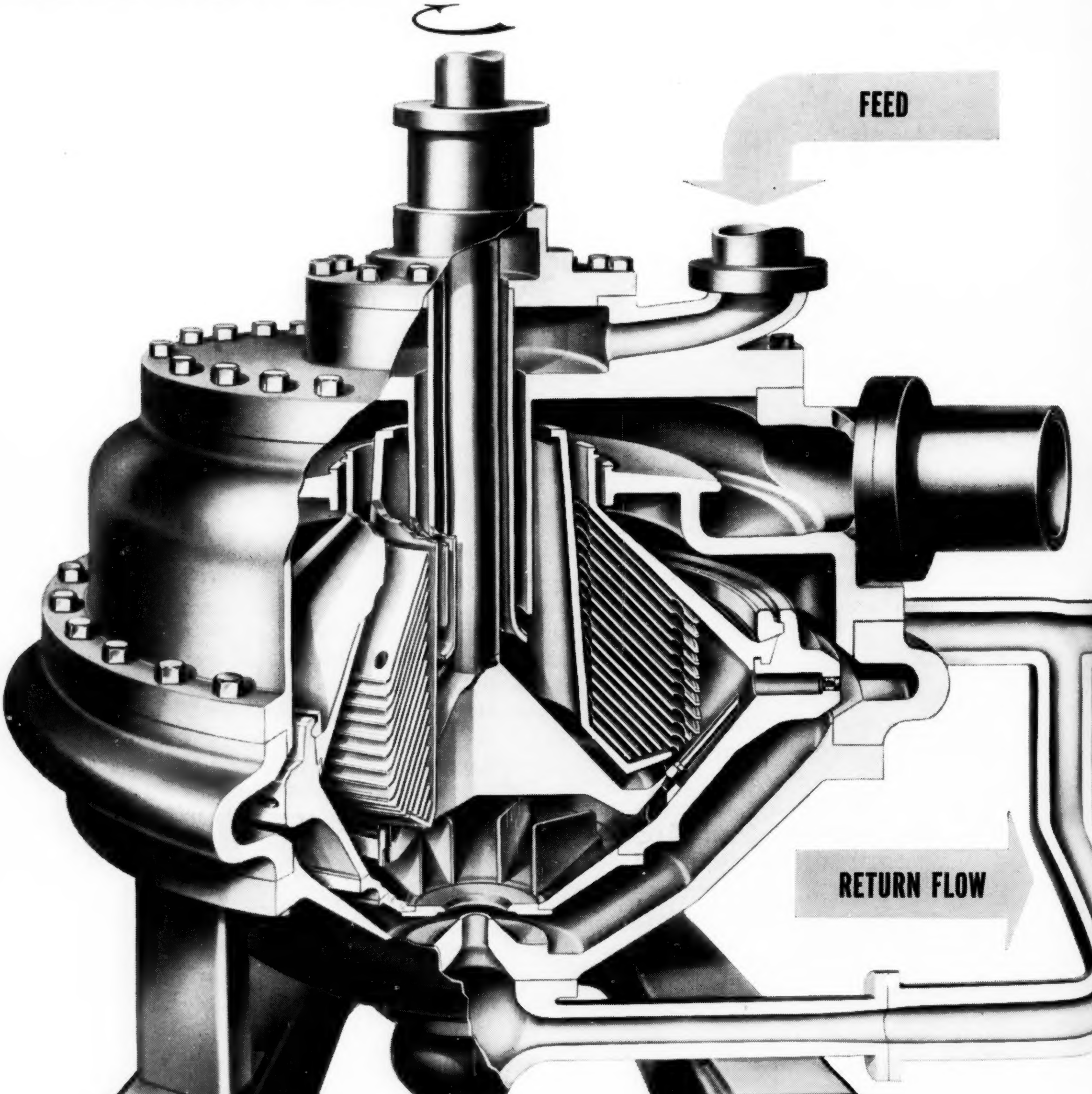
By June Mallory-Sharon Titanium Corp. will have in operation a large-scale pilot plant (cost: "several hundred thousand dollars") for

(Continued on page 142)

NOW

Centrifugal Separations

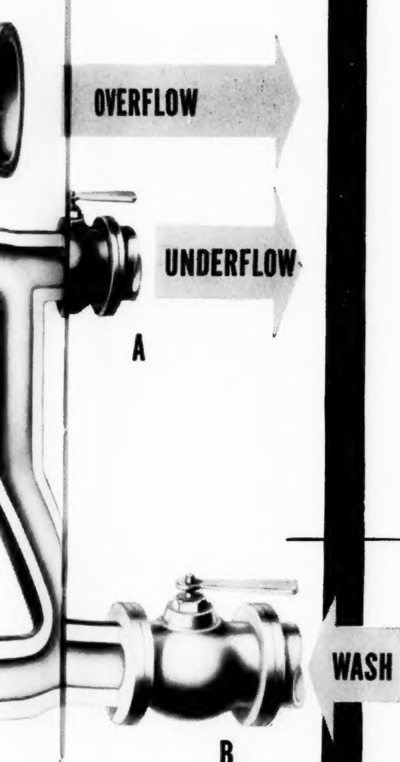
new Merco



under pressure conditions with the

Pressure Centrifuge

Illustrative drawing of Merco Pressure Centrifuge. In this example, wash is being introduced into recycle line at point B. If no wash is required, valve at B is closed. Concentrate is withdrawn at point A.



Newest development in wet processing equipment, the Merco Pressure Centrifuge is designed for all continuous centrifuging applications at pressures up to 110 psi. Key to pressure operation is a specially designed housing closure that has been exhaustively tested at pressures two to three times the guaranteed figure of 110 psi. Equally important, this new unit incorporates the unique Merco "Return Flow" principle for maximum operating flexibility. Under centrifugal forces thousands of times higher than gravity, even the smallest particles in the feed "sink" rapidly outward and are continuously expelled through fixed open nozzles in the rotor. A controlled portion is withdrawn as finished concentrate and the remainder becomes a return flow to the rotor. Wash, if desired, is introduced to the return flow line . . . clear, excess liquor overflows out the top of the unit.

If there's a step in your flowsheet involving concentration, washing, clarification, soluble recovery, or classification *under pressure*, there is a good chance that this new tool will prove useful. Bulletin No. 2600, just off the press, describes the Merco Pressure Centrifuge in detail. For your copy, write Dorr-Oliver Incorporated, Stamford, Conn.

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Pressure Operation — Concentration, washing, clarification, soluble recovery or classification can be carried out under pressure.

No Solids Build-up — All solids entering the unit are continuously discharged. Return flow flushes solid material at periphery of rotor.

No Nozzle Clogging — Return flow principle permits nozzle flow 2 to 10 times as great as the underflow actually withdrawn. Merco nozzles will discharge particles as large as 1/32 inch.

Practical Design — All separating conditions are controlled externally. The unit is equipped with a sturdy housing which has been X-rayed and hydrostatically tested.

reclaiming titanium from scrap by a newly developed electrolytic process. Company spokesmen say the process will yield extremely pure metallic titanium crystals.

With off-grade titanium sponge—as well as scrap metal—a problem to producers and users, other firms are reported interested in the process.

But the process may have more potential as a finishing step in primary reduction processes. Producers could bypass purification of raw materials and make a crude titanium sponge. Used as the anode in the cell, this sponge could be refined into a high-purity final product.

Developed by R. S. Dean and B. B. Raney of the Chicago Development Corp. and now in a 5-lb./day pilot unit, the new process, while called electrolytic, differs markedly from other electrolytic processes (*Chementator*, Feb. 1953, p. 103; Oct. 1954, p. 112; Jan. 1957, p. 110). There are relatively few titanium ions present in the electrolyte, and cell voltage and power consumption are low.

The electrolyte is described as a single-phase, three-component liquid containing $TiCl_2$ and $TiCl_3$ in equilibrium with dissolved sodium.

Cell anode is a bed of scrap particles held in a basket. Titanium in the scrap goes into solution as $TiCl_2$ and begins diffusing to the cathode. At the cathode, sodium reacts with the $TiCl_2$ to form NaCl and deposit the titanium in large, coarse crystals. In essence, the process is sort of an *in situ* sodium reduction.

Since TiO_2 and other contaminants are insoluble in the electrolyte, the Ti crystals are extremely pure. In fact, to take full advantage of this high purity, inventors Dean and Raney feel that new alloying methods will have to be developed, since current methods reintroduce some of the impurities.

Add another isomerization process

Add Iso-Kel to the list of octane-boosting petroleum isomerization processes (*Chem. Eng.*, Nov. 1956, p. 128) now available to the refiner. Developed by M. W. Kellogg, the new process boasts marked economic advantages, including lower equipment costs. Only one reactor is used and two separate products are made.

Process details on Iso-Kel are under wraps at present, but Kellogg does reveal that the process involves a vapor-phase reaction in the presence of hydrogen and a precious metal catalyst (not platinum, as in some other isomerization methods). Hydrogen-rich gas is charged to the reactor with a mixed pentane-hexane feed. After isomerization, the hydrogen-rich gases are separated and recycled. Reactor effluent is debutanized and depentanized, and isopentane and isohexane recovered as products.

Isopentane can go into super premium gasoline, isohexane to lower-octane grades.

Kellogg says that the process can also be used economically on natural gasoline.

Steel pinch means more building delays

With chemical industry expansion announcements coming thick and fast these days, today's steel pinch is going to squeeze even tighter in the months ahead.

Most steel makers say they'll go ahead with planned expansions despite the government's refusal to grant the industry the accelerated amortization allowances industry says it needs. But some projects will likely be deferred for lack of ready cash, and the gap between demand and supply will widen.

Plate and structural steel—critical items to the fast-expanding chemical industry—are hardest to get. Seamless pipe is also short.

Already, construction delays are piling up, and on-stream dates are being pushed back on many projects. And observers look for the situation to get a whole lot worse before improving. A price rise in steel is certain.

TVA fertilizer research moves ahead

In its recently released annual report the Tennessee Valley Authority gave industry another look into its research labs at processes now being developed to improve products and methods of fertilizer manufacture.

New developments include:

• Superphosphoric acid that is 40% more concentrated than the ordinary electric furnace acid, yet a fluid at ordinary temperatures. A product of elemental phosphorus, it offers shipping economies and may serve as a raw material for high-analysis liquid fertilizers.

• Granular fertilizers with good physical properties, made by treating calcium metaphosphate with sulfuric or phosphoric acid,

(Continued on page 144)

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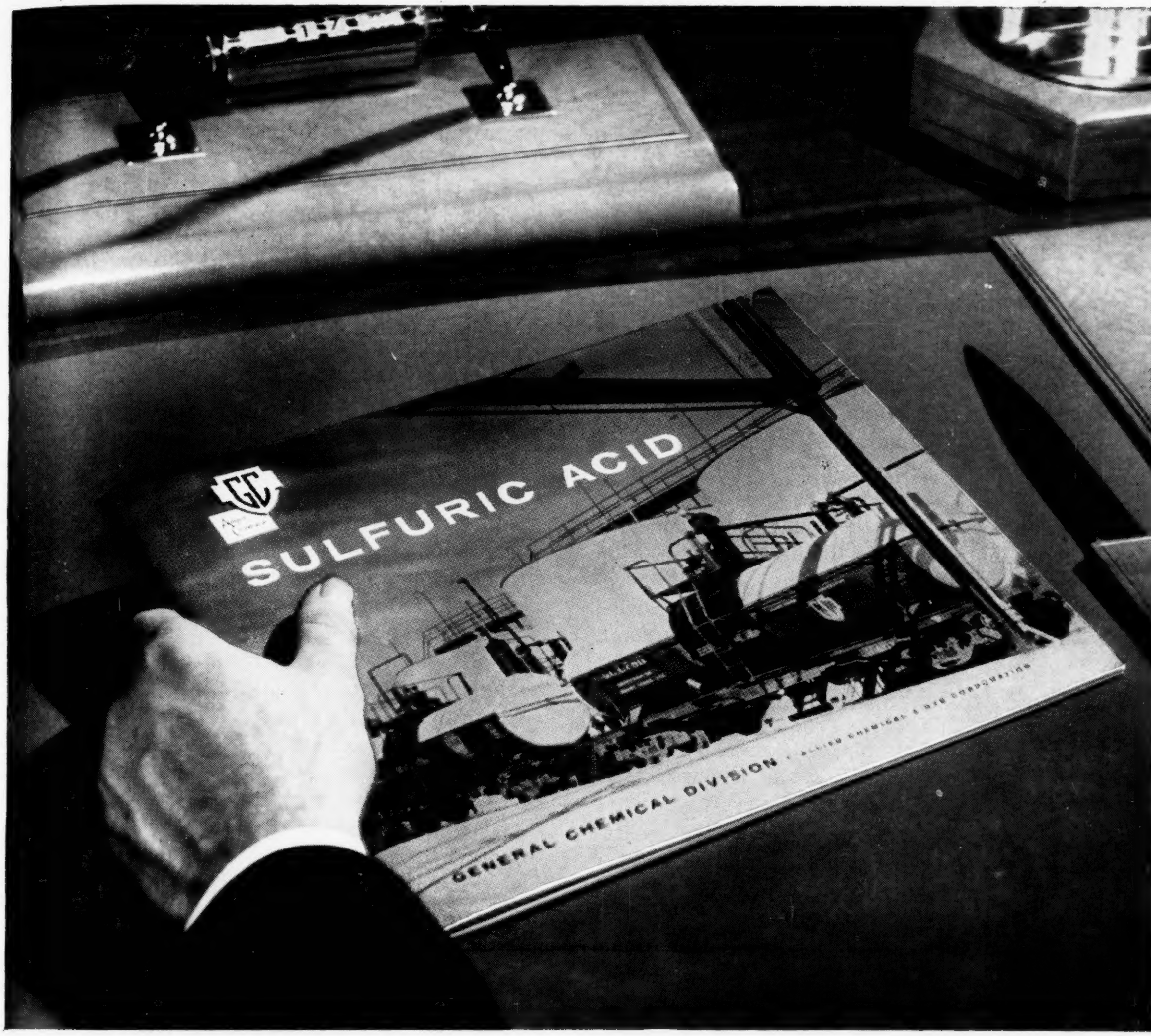

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then ammoniating with nitrogen solution or ammonia.

• Ordinary superphosphate in which 96% of the phosphate is in a form available to plants only an hour after mixing, made by using finer phosphate rock and high acid-to-rock ratios. Normally, weeks or months of storage are required for curing. The new product is ready for immediate ammoniation and mixing with other ingredients.

• Wet-process phosphoric acid, which is cheaper than furnace acid but less pure, was ammoniated by a technique that held impurities in relatively stable suspension. Material was put on eight acres with standard equipment. There was none of the usual plugging of pipes, pumps and nozzles.

• Design of a demonstration-scale unit to make high-analysis fertilizer from Florida "leached-zone" phosphate ore. Now an economic waste, "leached-zone" ore discarded yearly has 1,500,000 tons of plant nutrient.

Look for patent law changes

It is now certain that Congress will put the country's patent laws and the way they are administered under close scrutiny.

A series of reports on the various aspects of the patent system have been presented for congressional guidance and hearings are expected to get underway soon.

First report, from Dr. Vannevar Bush, contained a series of proposed changes, mainly designed to simplify the now-complex system to better serve the needs of inventors, business and consumers.

Another report reviewed the patent system in terms of its function in today's economy, while still a third analyzed ownership of patents issued since 1939.

Almost a score of reports on other phases are now in preparation. They will be used in hearings later this year to bring patent laws—scarcely changed in over a century—into line with today's needs.

New method portends small tall oil units

Spence & Green Chemical Co. has developed an anhydrous technique for fractionating tall oil and vegetable oil residues that is said to lower the costs of refining these materials. In operation since last November in a 15-ton/day unit at Houston, the method's relatively low investment and operating costs make small, mill-site plants economically attractive for the first time.

The unit could be installed at a pulp and paper mill, for example, to handle the relatively small volume of tall oil recovered by the typical mill, split this oil into rosin and fatty acid fractions and send the rosin on to be used as sizing in the paper mill.

S&G reports that such an installation could make rosin and fatty acid at a cost of \$75/ton—against \$105/ton for these products when steam fractionation is used—based on charging crude tall oil at \$50/ton.

Anhydrous fractionation under a vacuum of 300 microns is the major feature of the new method. Conventional plants use steam distillation or fractionate at a vacuum of about 5 mm. Hg. S&G says its method keeps costs down through equipment simplification, use of lower operating temperatures, reduced corrosion and savings on steam.

Not restricted to tall oil, the technique has also been used on cottonseed fatty acid residues. Other vegetable oil residues could also be used.

Since patents haven't issued, S&G is reluctant to talk about details of the method. But the company is prepared to discuss installation of a unit on a royalty or long-term-contract basis.

Pace quickens in oil sands work

Oil industry and government officials have started pushing plans to step up activity in getting oil out of the vast oil sands deposits in northeastern Alberta. The Suez crisis is chiefly responsible.

As a first step, a group of ten oil companies has reactivated an old committee to coordinate cooperative work on development of the properties they hold.

In another phase, a \$60-million development project will be launched in the region by companies now unnamed. This will involve a 30,000 bbl./day plant to convert the bitumen into a pumpable crude-oil-like material.

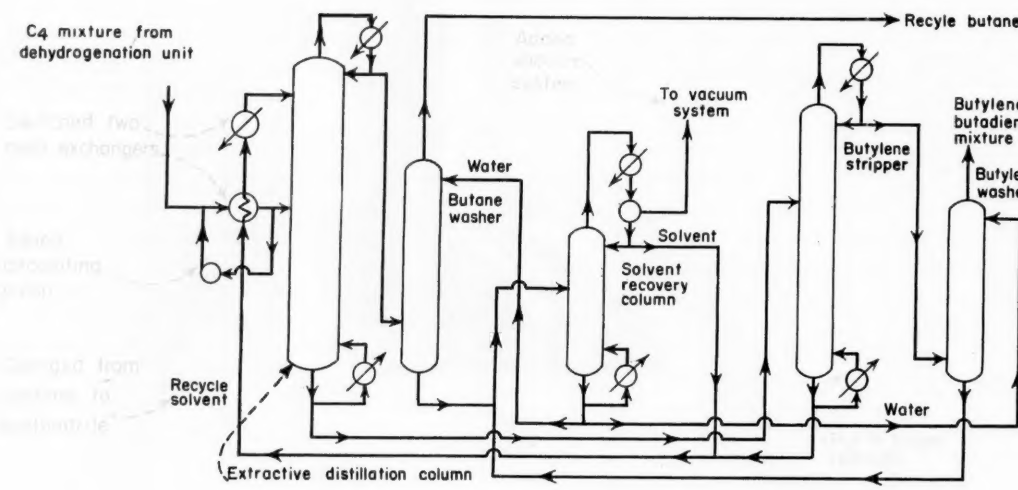
Announcement of a market for this oil is expected in a few months. Names of firms involved will be revealed at that time. Belgium and Great Britain are rumored to be likely markets, with Can-Amera and Royalite Oil (*Chem. Eng.*, Jan. 1957, p. 138) probably the firms involved.

For more on DEVELOPMENTS.........146

DEVELOPMENTS . . .

PROCESSES & TECHNOLOGY

C. H. CHILTON, SENIOR EDITOR



Revamp Nets Extra Capacity—Cheaply

Shell boosts throughput of butadiene feed-preparation unit nearly 60% via switch in extractive distillation solvent and other minor changes.

For an outlay of $148,000, plus some smart chemical engineering development work, Shell Chemical Corp. got nearly $3-million worth of added distillation capacity for its butadiene plant at Torrance, Calif.

Substitution of acetonitrile for acetone as the extractive distillation solvent did the trick. This move, which took place last August, boosted feed-preparation capacity by 58%—from 2,100 bbl./day to 3,000 bbl./day. Since duplication of the entire unit would have cost about $5 million, Shell figures it got the added capacity at a bargain rate.

Advantage of acetonitrile over acetone lies in its greater effect in spreading apart the boiling points of the C_4 hydrocarbons in the mixture being distilled. Critical separation is between normal butane and alpha-butylene. Relative volatility of these two hydrocarbons is about 1.20-1.25 when using acetone as the solvent; with acetonitrile, it's close to 1.50.

▶ **Expanding Rubber Demands**—Shell bought the government-built Torrance plant in April 1955 when the nation's World War II synthetic rubber facilities were sold to industry.

Early last year, Shell realized that continued growth of styrene rubber consumption would soon call for expansion of butadiene production. In analyzing their Torrance facilities, Shell engineers concluded that it would be a relatively simple matter to boost output of the other units in the butadiene plant—such as the liquid-liquid extraction of butadiene from butane-free butylene-butadiene mixtures—once additional butane-free feed were available.

This focused attention on the real bottleneck—the feed-preparation unit. Shell would either have to add another extractive distillation column or find a better solvent than acetone.

▶ **Picking a Winner**—Shell's engineers started exploring alternative solvents in earnest. By spring they had completed their bench-scale development and plate-by-plate calculations, were ready to try acetonitrile directly in the main 12½-ft.-dia. by 180-ft.-high extractive distillation column.

Shell decided to bypass pilot-plant work entirely. For one thing, the pilot-plant study would have cost about $50,000—a sizable figure in view of the estimated total cost for making the switch in the feed-preparation plant. For another thing, Shell wanted the additional capacity in a hurry. Besides, there's always some uncertainty in extrapolating from small-scale distillation runs, and

Shell's engineers were confident the process would work.

And work it did. All it took—besides the change in solvent—was a switch in service of two heat exchangers, a larger reboiler, an additional pump and conversion of the solvent recovery column to vacuum operation.

▶ **Like a Charm**—The 71-tray column started on acetonitrile during a plant shutdown in July, using a synthetic feed. It worked even better than expected. When the plant started up again on Houdry butane dehydrogenation ends, the column stayed on acetonitrile.

Shell expected some trouble in degradation of acetonitrile to ammonia and acetic acid, but this was minimized by keeping the system essentially neutral, as it was on acetone. Nor was there any need to change the operating pressure of the column; the close parallel in physical properties of acetone and acetonitrile is a fortuitous coincidence that made the conversion relatively simple.

Shell engineers also expected problems with the water balance in the system. Actually, they found that they could reject more overhead water in the butylene stripper than they had predicted; presumably, acetonitrile forms a ternary azeotrope. And though too early to determine actual experience, Shell now expects no increase in corrosion rates because of the switch.

▶ **Dash of Bitters**—Shell's only disappointment is that acetonitrile costs about 45¢/lb., compared with about 8¢/lb. for acetone. Present losses are somewhat less in quantity than with acetone but are appreciably higher in dollar cost.

It behooves Shell to cut that loss. Already Shell is installing vent scrubbers, better pump seals, etc., expects to reduce physical losses to the point where dollar value is of the same order as acetone.

▶ **Not as a Stranger**—Shell Development Co., Emeryville, Calif., did basic research and obtained basic patents on extractive distillation processes in the early 1940's. Big push at that time was to get butadiene plants running—and fast. Shell settled on an aqueous acetone system because of the ready availability of acetone as compared with other possible solvents, such as nitromethane, methyl formamide and acetonitrile.

In the meantime, work went on in many laboratories throughout the country, developing added knowledge of extractive distillation systems, not only for C_4 separations but also for separations of C_6 and C_7 cyclic hydrocarbons. Chemical engineers at the University of Illinois found, for example, that both nitromethane and acetonitrile were especially effective in separating aromatics from naphthenes.

Shell Development, however, has patents covering the use of acetonitrile for the separation of olefins from paraffin-olefin mixtures. The company is willing to license this process in the same way it has licensed other extractive distillation processes.

▶ **How Process Works**—The feed-preparation unit takes butane out of a butane-butylene-butadiene mixture from a butane dehydrogenation unit. Another unit separates the butadiene and butylenes,

with the butylenes then being further dehydrogenated to form more butadiene.

Feed-preparation unit consists of five columns, plus auxiliaries, to do these jobs:

- Extractive distillation column, to separate butane from the other C_4's.
- Butane washer, to recover solvent from the extractive distillation overhead.
- Butylene stripper, to separate butylene and butadiene from solvent.
- Butylene washer, to recover solvent from butylene stripper overhead.
- Solvent recovery column, to reconcentrate solvent for recycling to the extractive distillation column.

▶ **Equipment Changes**—To put the solvent switch into operation, Shell needed a larger reboiler on the butylene stripper because of acetonitrile's higher boiling point (176 F. vs. acetone's 131 F.).

Heat exchangers for the feed vaporizer and the solvent cooler were switched to balance the new requirements of heat-transfer surface. Greater cooling surface was needed; acetonitrile comes from the butylene stripper about 40 F. hotter than the acetone did. The smaller feed vaporizer

was made adequate by putting in a forced-recirculation pump to give a better heat-transfer coefficient and less fouling.

Finally, a vacuum system was provided for the solvent recovery column because of the more favorable overhead azeotropic composition and generally higher acetonitrile-water relative volatility at the lower pressure.

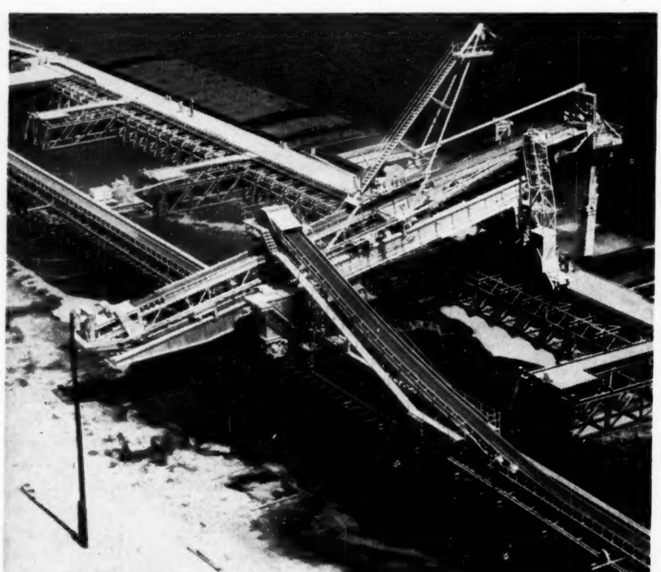
Reactor-Building Mounts Here and Abroad

Within recent weeks has come an outbreak of announcements by American firms of orders to build atomic reactors for use abroad, and Argonne National Laboratory in Lemont, Ill., announced completion of a new experimental nuclear reactor which it describes as revolutionary in design.

Known as a "slow-fast" reactor and designated as Zero Power Reactor No. V (ZPR-V), the Argonne installation is not designed to produce electrical power but will be used to facilitate studies of the fundamental principles upon which future large power reactors may be designed and built.

ZPR-V is, in a sense, a reactor within a reactor. The entire unit consists of a 5-ft.-dia. steel tank in which the uranium fuel assemblies and the control rods are placed. In the center of this tank is the "fast" reactor section, which contains 49 enriched-uranium fuel assemblies which are placed in a 2-ft.-square section. Surrounding this "fast" reactor section is the "slow" reactor section, which consists of normal and enriched-uranium fuel elements arranged in a geometric pattern around the "fast" core section and immersed in water. The new reactor is unique in that the nuclear chain reaction takes place in both regions, although they have entirely different nuclear properties.

Abroad, Sweden, Italy, Venezuela and Canada have all ordered atomic reactors from U. S. companies. Venezuela has ordered its first atomic reactor, to be used by the government biophysics and nuclear physics research center near Caracas, from General Electric's atomic power equipment department at San Jose, Calif. AMF Atomics (Canada), Ltd., AMF subsidiary, will design and build the first privately owned and operated nuclear research reactor in Canada. A pool-type design, it will be built at McMaster University, Hamilton, Ont. Vitro Engineering Div. has received a contract for engineering service on a CP-5-type nuclear reactor facility to be built in Milan for Italy's equivalent to the U. S. Atomic Energy Commission. A 30,000-kw. light-water nuclear research and materials-testing reactor—one of the largest such facilities yet proposed anywhere in the world—will be built in Sweden under terms of an agreement just signed between the Atomic Energy Co. of Sweden and ACF Industries.



Sulfur Ship-Loader Halves Time for Dock Operations

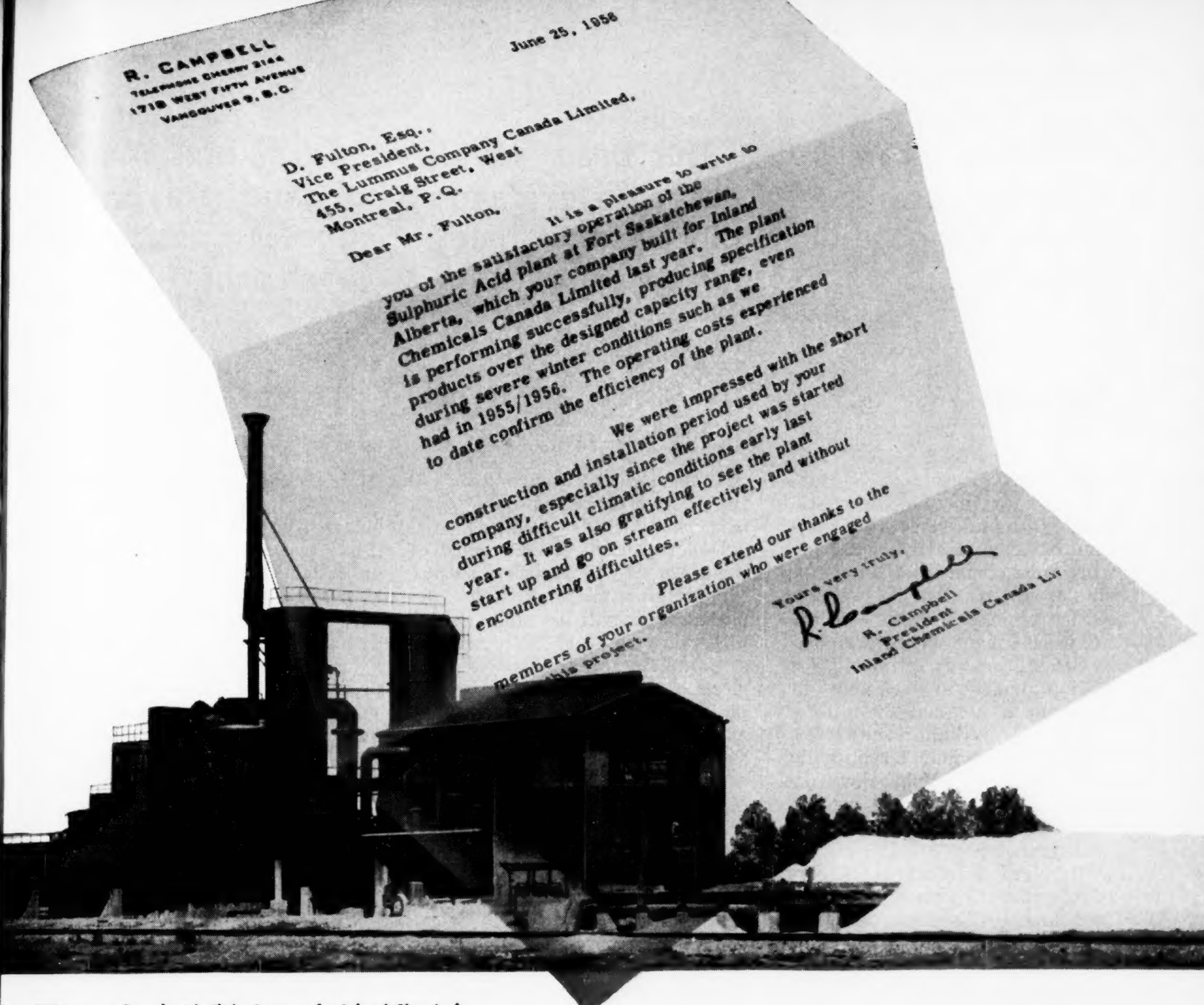
A foot-square panel of buttons controls the $\frac{3}{4}$-mi. conveyor belt system and moves the loader and chute which make up new $1-million sulfur dock facilities installed by Freeport Sulphur Co. at Port Sulphur, La. Designed by Hewitt-Robins, the giant machine travels a distance of 400 ft. on two sets of double rails and moves from one ship's hold to another in less than 5 min., contrasted to 30 min. if the ship had to be moved.

Three Plants Set For Uranium Processing

Atomic Energy Commission has authorized Lucky Mc Uranium Co. to build a $7-million uranium processing mill in the Gas Hills area of Wyoming; has contracted to buy concentrates from a $2-million mill being built by Gunnison Mining Co. in Gunnison, Colo., and from a Trace Elements Corp. mill under construction in Grand Junction, Colo.

The Lucky Mc mill will be capable of processing 750 to 1,000 tons of ore daily. This will probably be the largest concentrator to use columnar ion exchange process.

AEC states that 12 uranium processing mills are now operating. Contracts for at least eight additional mills, including those above, have been signed.



R. CAMPBELL
TELEPHONE CHERRY 3144
1718 WEST FIFTH AVENUE
VANCOUVER 9, B.C.

June 25, 1956

D. Fulton, Esq.,
Vice President,
The Lummus Company Canada Limited,
455, Craig Street, West
Montreal, P.Q.

Dear Mr. Fulton,

It is a pleasure to write to you of the satisfactory operation of the Sulphuric Acid plant at Fort Saskatchewan, Alberta, which your company built for Inland Chemicals Canada Limited last year. The plant is performing successfully, producing specification products over the designed capacity range, even during severe winter conditions such as we had in 1955/1956. The operating costs experienced to date confirm the efficiency of the plant.

We were impressed with the short construction and installation period used by your company, especially since the project was started during difficult climatic conditions early last year. It was also gratifying to see the plant start up and go on stream effectively and without encountering difficulties.

Please extend our thanks to the members of your organization who were engaged this project.

Yours very truly,

R. Campbell

R. Campbell
President
Inland Chemicals Canada Lir

100-ton per day plant built by Lummus for Inland Chemicals Canada Limited went onstream 9½ months after the contract was signed, 7 months after field work began.

This sulfuric acid plant was—

Finished fast... started smoothly... is going fine!

Winter is rugged at Fort Saskatchewan, Alberta. In spite of it, this $1,000,000 sulfuric acid plant built there by Lummus was completed well ahead of schedule, and was making specification product within 12 hours of startup.

That was a year ago. Since then this plant has been producing to specification over a range of capacities from 45 to 125% of design.

Why not talk to Lummus before you start your next project?

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N. Y.
***Engineering and Sales Offices:* New York, Houston, Montreal, London, Paris, The Hague, Bombay.**
***Sales Offices:* Chicago, Caracas.**
***Heat Exchanger Plant:* Honesdale, Pa.**
***Engineering Development Center:* Newark, N. J.**

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

Starting with aromatic hydrocarbons of any composition or purity . . . ➡ This basic liquid-phase air oxidation process, now ready for plant use . . . ➡ Turns out mono-, di- and polybasic aromatic acids at low cost.

Versatile New Route to Aromatic Acids

Scientific Design Co.'s process for making aromatic acids via liquid-phase air oxidation of aromatic hydrocarbons will get its commercial launching with a new plant to be built by Amoco Chemicals Corp.

Amoco's plant, being designed by SD, will cost an estimated $10 million and will be able to turn out a nominal 60 million lb./yr. of phthalic anhydride, isophthalic acid, terephthalic acid, dimethyl terephthalate, dimethyl isophthalate and benzoic acid. It's expected on stream next year.

Standard Oil Co. (Ind.), corporate parent of recently organized Amoco Chemicals, has just bought exclusive world-wide rights to the process, originated and pilot-planted by SD and its associated companies at their Port Washington (N. Y.) laboratories. SD will serve as Standard's licensing agent for the process in foreign countries. (First licensee abroad is Pechiney in France; another license has already been granted to an unidentified company, and two more are being negotiated.) SD hopes, in addition, to win some of the engineering and construction contracts involved.

▶ **Uses Mixed Xylenes**—Distinctive feature of SD's oxidation process (to be known in the Indiana organization as the "MC" process) is its versatility with regard to starting materials as well as to products.

Process can start with aromatic hydrocarbons of any composition or purity, can convert them to the corresponding mono-, di- and polybasic aromatic acids. Specific conditions will determine whether to refine the feed stock or the products. Amoco will use a single source of mixed xylenes, probably separate the mixture of phthalic acid isomers which is produced.

Under present market conditions Amoco will doubtless shoot for maximum production of phthalic anhydride and terephthalic acid (or its dimethyl ester). Benzoic acid will be more of a byproduct. Whereas phthalic and terephthalic are made in the U. S. to the tune of some 350 million and 50-60 million lb./yr., respectively, sales of benzoic acid, the only commercial aromatic monobasic, amount to less than 1 million lb. Obviously, Amoco could flood the present benzoic market. On the other hand, a drastic price reduction in benzoic acid from its present level of about 44¢/lb.—certainly a logical expectation—could possibly open up entire new markets for benzoic.

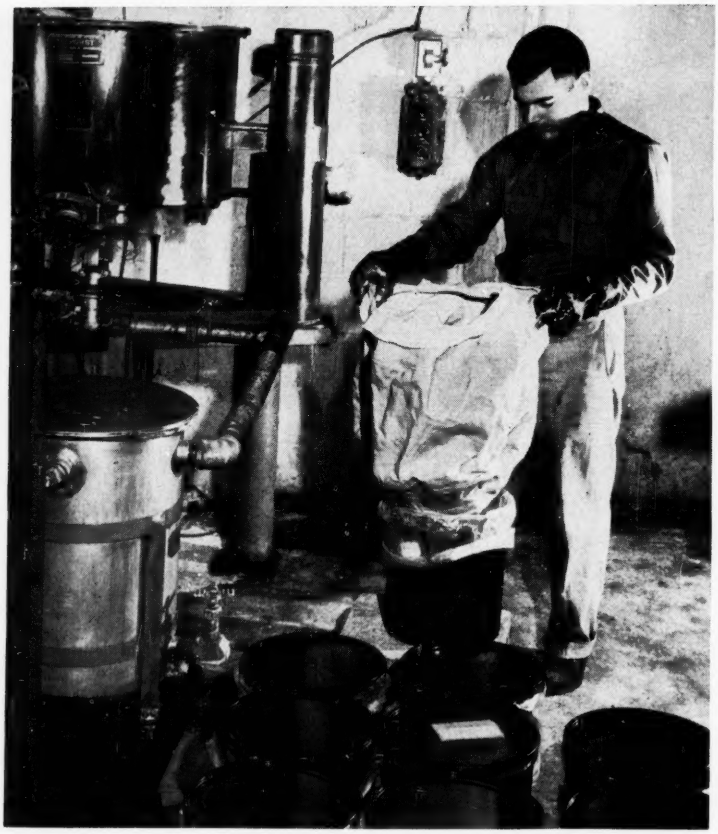
▶ **Still Secret**—Pending the granting of patent protection, Scientific and Standard are keeping mum on process details. No information can be published on pressure, temperature, catalyst, materials of construction, type of equipment or methods for separation of products.

SD will concede that process conditions are much milder than the 2,500-psi. pressure used by Oronite to make isophthalic acid from meta-xylene. On the other hand, the type of construction used in SD's pilot plant suggests pressures considerably greater than 150 psi.

▶ **MC vs. Competition**—Regardless of exact conditions used, the MC process boasts a versatility, simplicity and economy unmatched by any other commercial process in its field. In comparing this process with others, SD cites these points:

- Compared with conventional air oxidation of naphthalene to phthalic anhydride, MC uses a price-stable, virtually unlimited domestic source of hydrocarbon.
- Compared with vapor-phase air oxidation of ortho-xylene to phthalic (Oronite process), with its reported yields of 50-70%, SD claims "almost quantitative conversions."
- Compared with Oronite's liquid-phase process for making isophthalic via oxidation of meta-xylene at 2,500 psi. and high temperature with sulfur, ammonia and water, the MC process eliminates the cost of chemical oxidants and suggests lower capital costs.
- Compared with nitric acid oxidation of para-xylene to terephthalic (Du Pont), the MC process again avoids the cost of reagents and claims, in addition, higher yield and purer product.
- Compared with Hercules' complex four-step oxidation of para-xylene, the MC process is obviously simpler and more versatile.
- Compared with the Richfield-Stanford Research Institute two-step process (air oxidation plus nitric acid oxidation), using mixed xylenes, the MC process again is simpler and eliminates the cost of oxidant.
- Compared with Shell's liquid-phase air oxidation of tertiary butyl toluene to tertiary butyl benzoic acid, with maximum yields per pass of about 60% and ultimate yields with recycle of 85%, SD claims "almost quantitative yields" in single-pass operation without recycle.

▶ **Cheap Raw Material**—According to Ralph Landau, SD executive vice president, one of the



CENTRIFUGAL separation is final step in SD's pilot-plant operations.

most important fields of application of the MC process is in the oxidation of mixed xylenes such as are readily available from catalytic reformers or from coal-tar distillation plants. These mixtures are frequently sold in world markets at or about solvent prices, enabling the production of mixed dibasic acids directly at low cost.

Landau's original work on aromatic oxidation, however, was concerned with a specific, less-common starting material — para-diisopropyl benzene. Several years ago a prospective client asked Scientific Design to suggest an alternative route to terephthalic acid which might be competitive with oxidation of para-xylene. Landau came up with the idea of oxidizing para-diisopropyl benzene, which could be synthesized readily enough, like cumene, from propylene and benzene.

SD proceeded to develop in its laboratory an air oxidation process for making terephthalic from this synthetic intermediate,* then found to its amazement (and ultimate profit) that its oxidation technique could be made to do all the other things claimed above.

▶**Big Payoff**—Although Scientific Design is a relatively small company, its three owners decided to risk their limited resources in further development of the oxidation process. Three-shift pilot-plant operation began in January 1954 on a scale of several hundred lb./day. During 1956, Standard collaborated in the solving of specific process problems at Whiting on a somewhat smaller scale, culminating in Standard's recent decision to buy the process outright.

* SD has designed a terephthalic plant using this route for a European company.

Landau describes the oxidation process development as the SD group's most expensive venture to date, even though it cost SD less, he says, than it would have cost a large operating company. And he beams like a proud parent on commencement day when he also tags the project as SD's "most rewarding" one. It will provide SD with ample encouragement for future process-development programs.

More Petrochemicals For Mid- and Southwest

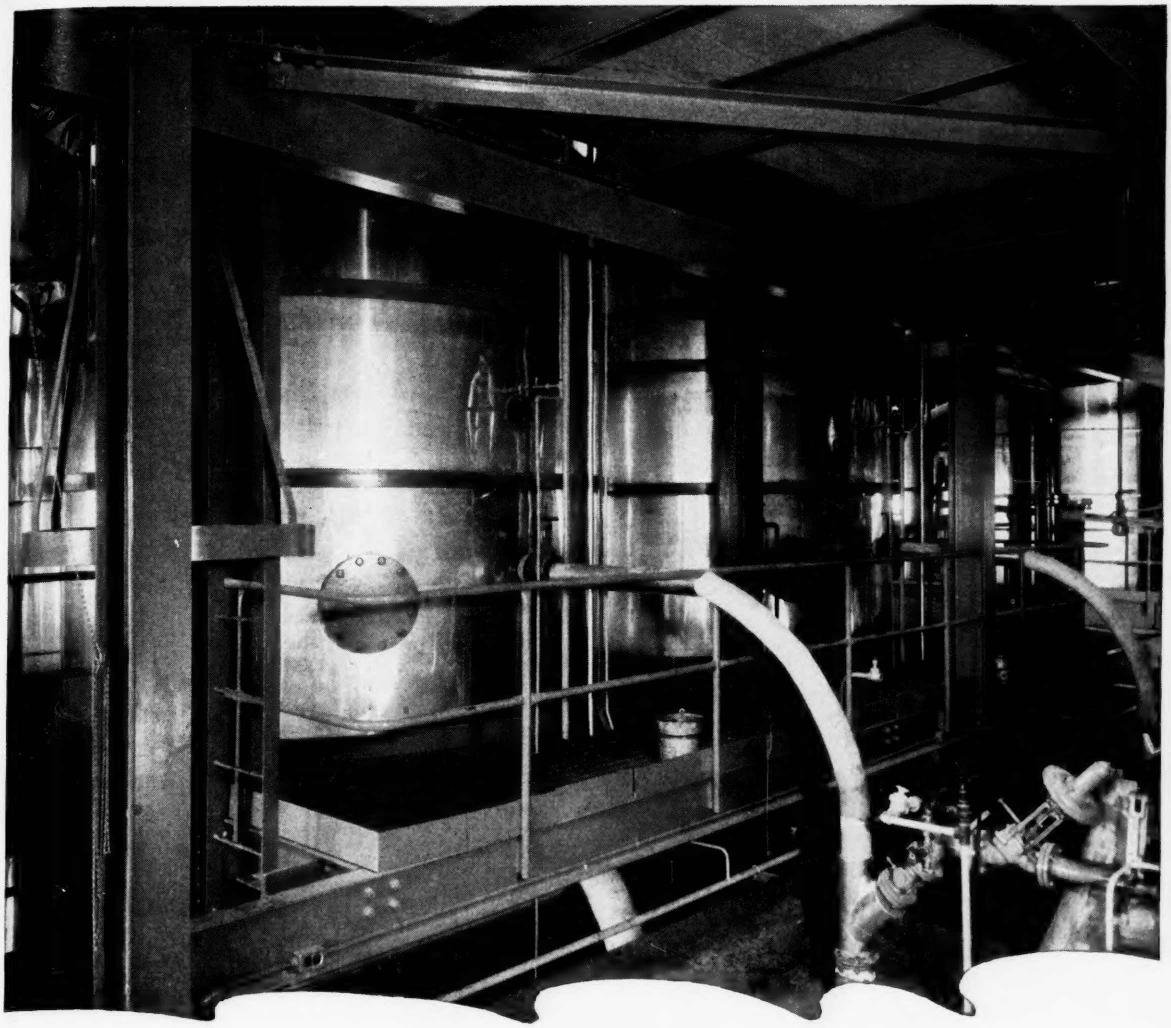
Jefferson Chemical Co. plans a $35- to $40-million expansion of its petrochemicals plant at Port Neches, Tex.; Petroleum Chemicals, Inc., has revealed that ethylene output of its multimillion-dollar petrochemicals plant under construction at Lake Charles, La., will be 200 million lb./yr.; Commercial Solvents Corp. and the Columbia Gas System, Inc., are considering expenditures of $40-$50 million on construction of new petrochemicals facilities in the Ohio Valley area.

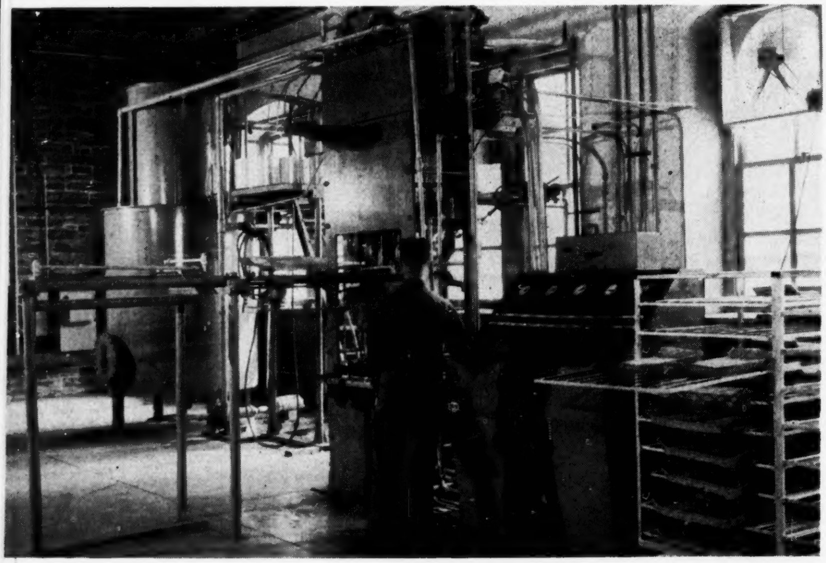
The Jefferson expansion will triple production facilities for ethylene, double capacity for ethylene glycol. It includes a new chlorine plant and stepped-up output of a number of specialty chemicals.

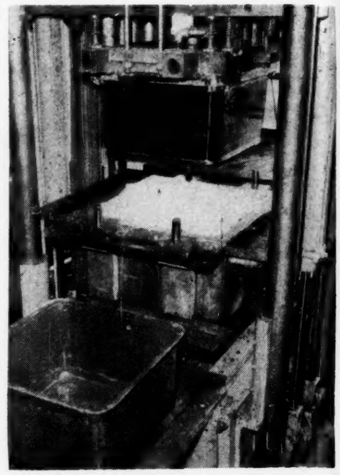
Third Big Plant For Isocyanates

At Moundsville, W. Va., National Aniline Div. has started up the third of the nation's isocyanates plants, all built within the past year. With a reported capacity of 6-7 million lb./yr. of these key intermediates for making polyurethanes, the new plant joins Du Pont's 25-million-lb./yr. installation at Deepwater Point, N. J., and Mobay's Moundsville plant, whose 10-17-million-lb. output is set to be tripled.

National Aniline has produced isocyanates in substantial volume at its interim plant at Buffalo since 1955. The Buffalo plant will continue to produce new isocyanates developed at the company's research center there.







1 **Cellulose binder is first dispersed in water.**
2 **Glass fibers are cut to length, mixed with slurry.**
3 **Cellulose-glass fiber slurry is molded into preform.**
4 **Preform is air-dried, ready for plastic impregnation.**

Preforms Made via Glass Fiber Slurry

PROCESS outlined above is designed to take the costly, time-consuming hand operations out of the manufacture of fibrous-glass-reinforced plastic articles which have nonuniform wall thickness.

This is done by forming, automatically and continuously, the glass fiber preforms for such articles. Thus mass-produced, application-tailored finished articles can sell at about half of going prices.

Big markets should open—in reusable military and industrial shipping and storage containers, in machine housings, in consumer products such as auto bodies and furniture, and many other items requiring bosses, ribs or flanges. For these types of applications, reinforced-plastic performance characteristics are often superior, but cost has been prohibitive.

Developed by Pressurform Co., Swarthmore, Pa., the new process has already been licensed to an affiliate, Pressurform Container Corp. (also at Swarthmore) and to Banner Fiberglass Products Corp., Paterson, N. J. The Swarthmore unit started production last April and is now supplying shipping containers for radar-jamming equipment to General Electric.

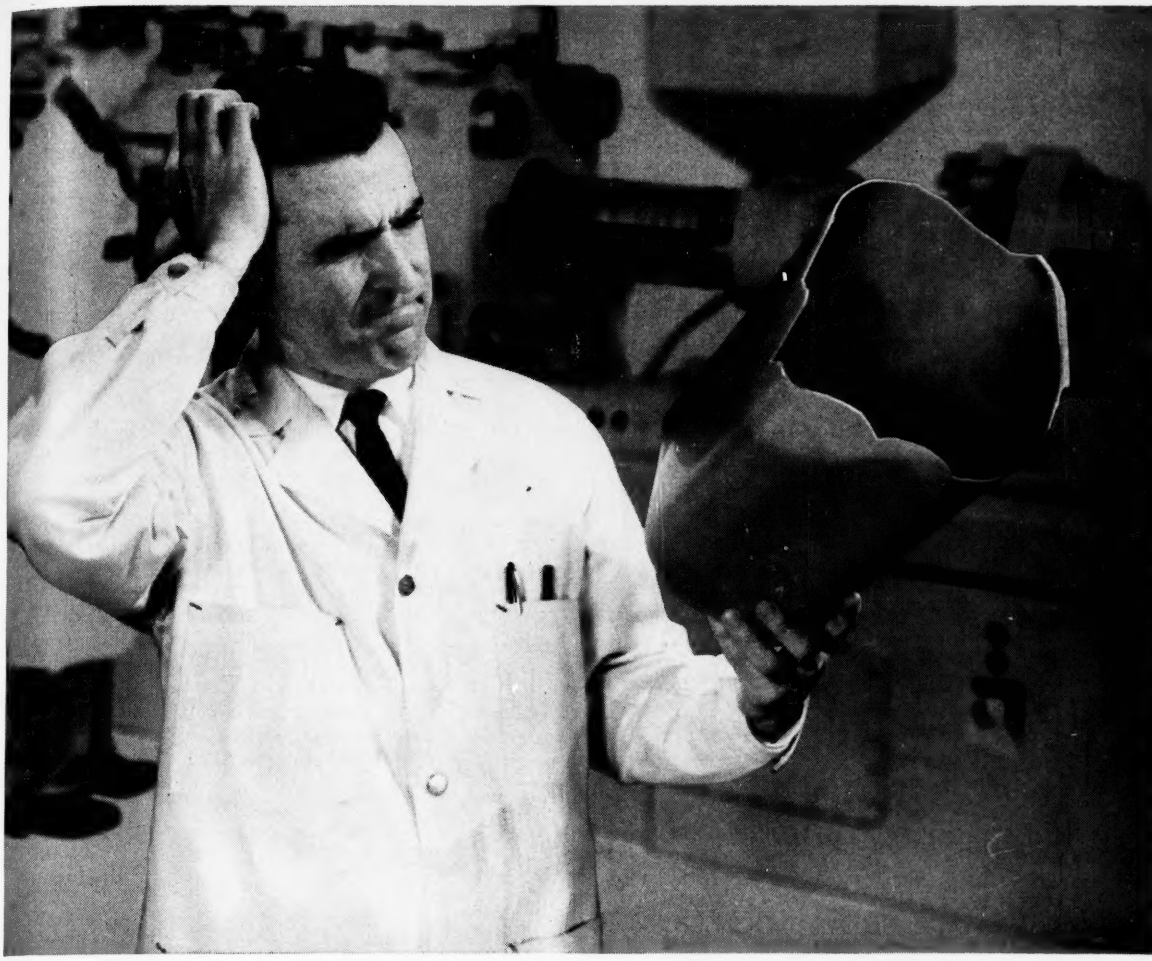
▶ **Forming the Skeleton**—The Pressurform technique makes an aqueous slurry of glass fibers and binder, raw materials for preforms. The preforms are precisely shaped skeletons of the finished products.

With slurrying comes the ease of liquids handling plus the ability to mold the fibrous glass as if it were a plastic; preform shapes are pressed out of the slurry in a mold, specially designed but related to those used in forming plastics.

▶ **No Hand-Tailoring**—It has always been relatively easy to make reinforced-plastic flat and corrugated panels—even contoured shapes—as long as section thickness was constant. But for contoured parts with varying wall thickness, glass mats had to be cut and tailored, contoured and hand-coaxed—with resin as a binder—to achieve shapes close to the desired skeletal form.

This difficult hand-tailoring, necessary before such parts could be molded with resin and heat-cured between matched metal dies, has held back development in the field. In addition to cost problems, quality control has been difficult, and good housekeeping has been impossible.

The Pressurform process promises easy, automatic fabrication of almost any preform shape. Any reasonable contour and any reasonable variation in section thickness can be achieved by Pressurforming. *(Continued)*



Injection Molders:
Are you using the wrong melt index?

Have you found the melt index that gives you *both* good flow characteristics and good "stress-cracking" resistance? Or are you plagued with production problems?

Now you can get the correct melt index resin. A-C POLYETHYLENE technical representatives can show you how to tailor-make the individual melt-index polymer that is exactly right for your product.

A blend of A-C POLYETHYLENE and the proper resin will enable you to get both good flow characteristics and good resistance to "stress-cracking." The use of A-C POLYETHYLENE results in these advantages, too: 1. lowered costs; 2. high gloss; 3. improved color dispersion; 4. increased or equivalent stiffness; 5. reduced cycle time; 6. decreased injection pressures; 7. better mold release.

Mail in the coupon today for assistance in tailoring a melt-index resin to your operation.

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Allied Chemical & Dye Corporation
Room No. 502-A
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Allied Chemical

I want assistance in developing the correct melt-index resin.

Name__________

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City__________

Zone_____ State__________

▶ **How It's Done**—Process starts with preparation of binder pulp. Instead of a conventional resin binder, Pressurform uses cellulose. With cellulose-water slurry is mixed glass roving cut into preselected lengths. These lengths can be varied between ¼ and ¾ in., depending on desired structural properties of end product.

Ratio of glass to cellulose in the slurry affects strength of product. Where strength is of lesser importance, proportion of cellulose can be raised to cut materials cost. (Cellulose costs 10-20¢/lb., compared with about 32¢/lb. for fibrous glass.) Synthetic, rather than cellulose, fibers can be used to obtain yet another variation in end-product quality.

Because proportions and volume of material are controlled automatically, variation in preforms is less than ½ oz. in 20 oz.

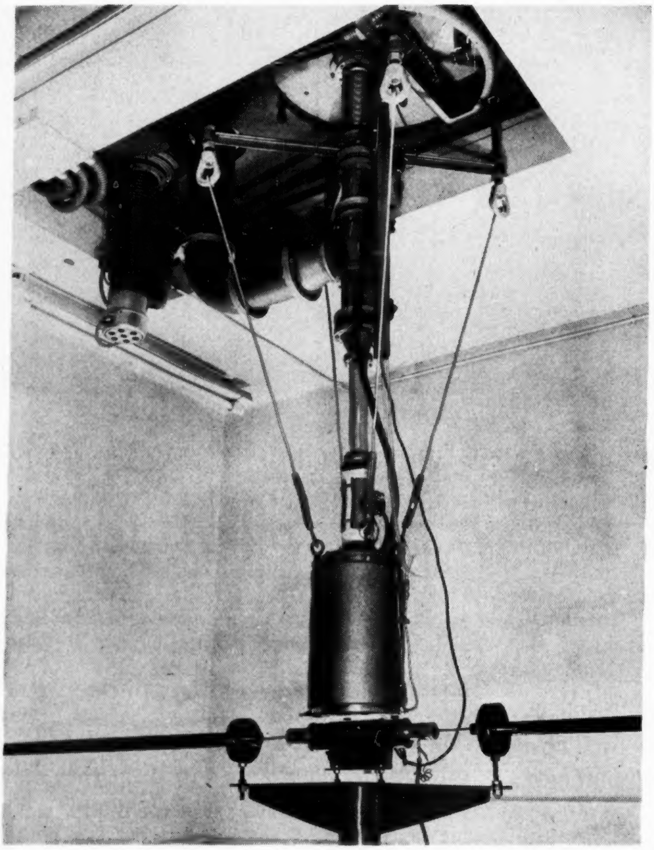
Preform mold operates at pressures varying from 30 to 100 psi. Slurry water squeezes out through perforations in the mold. Preforms are damp, but firm and accurately shaped.

After drying in an air oven, preforms are ready for impregnation with plastic (polyester resin, at Swarthmore) in the molding press. Preforms can be turned out in 30 sec. to 2½ min., depending on design—a fraction of the time required by conventional methods.

▶ **Everyone Benefits** — GE's radar containers made by Pressurform at Swarthmore provide a good example of the design flexibility afforded by the new technique. Strength is provided where needed by thickness at the corners; side walls are tapered for minimum container weight (two-thirds that of steel) and for most economic use of raw material.

Steel containers frequently used in this type of application cost $35 each, Pressurform containers cost $40, pre-Pressurform reinforced-plastic containers cost $120. Just the fact that, unlike plastic, the steel containers must be painted twice a year more than balances the price discrepancy between steel and Pressurform products. Even at pre-Pressurform prices, there has been some market—albeit small—for the reinforced-plastic containers because of their light weight and superior shock and corrosion resistance.

A typical Pressurform installation for producing preforms would cost in the neighborhood of $150,000. If set up to produce containers ranging in size between 12×12×16 in. and 28×28×22 in., that installation's production capacity would average about 64 containers/8-hr. day.



Electrons Modify Plastic-Coated Cable for Study

Property changes induced in polyethylene-coated cable by passage through 2-million-volt Van de Graaff accelerator's electron beam are now being studied by British Insulated Callender's Cables Ltd., London. Cable under radiation is handled by conventional take-up and haul-off cable machinery.

Better Way to Refine
Aromatic Hydrocarbons

Oil & Chemical Products, Inc., New York, has just been issued a patent for a process to remove finely dispersed sulfuric acid present in treated hydrocarbons in a manner technically simple and in a commercially useful form. Used for five years at the company's Houston, Tex., refinery, the process is said to have produced greater yields of ben-

zene, toluene and xylene, substantial savings in chemicals and recovery of valuable byproducts. The method avoids formation of emulsions; as a consequence, losses of desired aromatics are materially reduced as compared with those from other known processes.

More Pure Water Via Membranes

The largest plant in the world to electrically purify salt water has been put on stream by Bahrain Petroleum Co. at Bahrain in the Persian Gulf. To produce 86,400 gal./day of fresh water and supply drinking and cooking water for a community of 5,000, process used at Bahrain uses electric membrane demineralizers developed by Ionics, Inc., Cambridge, Mass. (*Chem. Eng.*, Oct. 1956, p. 185).

The electric-membrane process operates by use of selective cationic and anionic barrier membranes. An individual cell consists of an anion membrane and a cation membrane, separated by spacers to permit flow of saline water between them. The new plant consists of 15 basic desalting units; they are connected in three parallel banks of five series units. In the series, each of the five units removes up to 40% of the salt present at the beginning of the cycle. Input water of 3,100 ppm. dissolved solids is converted to product water of less that 450 ppm. dissolved solids.

Smaller plants using the process are already in operation in the United States.

Liquid Fertilizers Give New Look to Plant Interiors

Small, neat look of Davison Chemical Co.'s 15-ton/hr. complete liquid fertilizer plant at Wakarusa, Ind., typifies the new silhouette in fertilizer equipment. With many small plants located close to markets, increasingly important complete liquids are made by neutralization of phosphoric acid with ammonia, shown above, subsequent addition of urea and potash. Davison uses a batch process, which provides for production of aqua ammonia, ability to cool during the neutralization process and maintenance of proper balance of ammonia and phosphoric acid by means of a pH meter.

New Formaldehyde Plant; New Process Direction

Latest addition planned for Reichhold's chain of formaldehyde plants, a $225,000 unit at Tacoma, Wash., will use an iron-molybdenum-oxide process developed at the company's Seattle plant (*Chem. Eng.*, Nov. 1954, pp. 109-110). This probably cues the process direction for all future company expansions in formaldehyde.

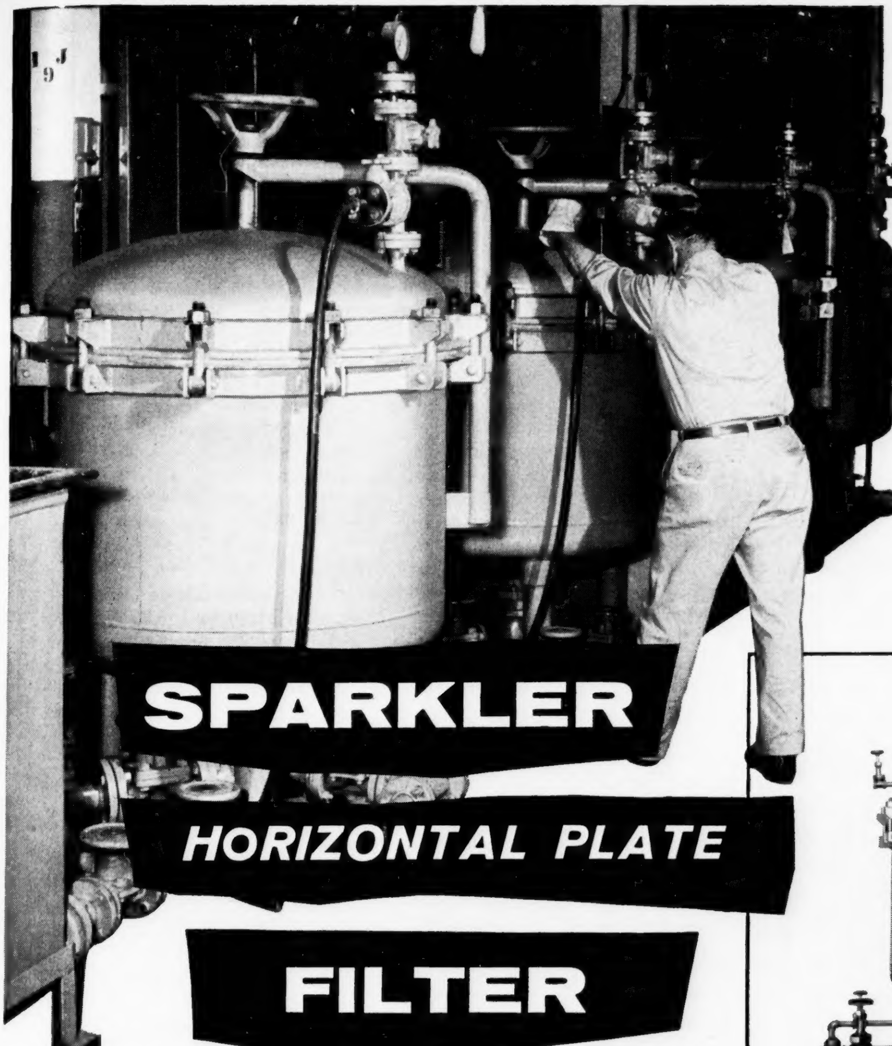
Reichhold's older formaldehyde units in Massachusetts, North Carolina and Alabama continue to use conventional silver catalyst for the basic step—oxidation of methanol with compressed air. However, low construction cost makes the new process, based on metallic oxide catalyst, one that could be economically located anywhere in the country where formaldehyde is needed.

Capacity of the new plant has not been announced, except that it will increase the firm's Pacific Northwest formaldehyde capacity by 75%. Initial capacity of the firm's Seattle plant, only other one in the region, was 2 million lb./mo., since increased.

Northwest Pulpers Unite To Study Pollution

Recognizing public pressure for air- and water-pollution abatement, 16 Washington and Oregon pulp and paper mills have formed the Northwest Pulp & Paper Assn. as a permanent research and educational organization.

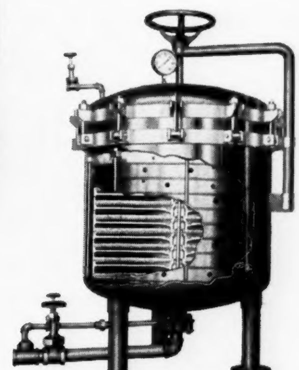
One association member, Rayonier, became target of a damage suit, filed by Puget Sound oyster growers last June and now reaching the courts, charging that Rayonier's Shelton, Wash., discharges are responsible for a high mortality rate among the oysters. The Washington State Pollution Control Commission has refused to give the company a permit to continue its present method of waste disposal.



SPARKLER HORIZONTAL PLATE FILTER

SPARKLER *horizontal plate* FILTERS

The filter that for 25 years has featured perfect cake stability. The time tested, proven superiority of the horizontal plate principle has been accepted to the extent that in recent years this horizontal position of the cake has been the most copied design feature of any filtration principle by filter manufacturers all over the world.



Sparkler Horizontal Plate Filter. The cake maintains its original position as formed regardless of pressure fluctuation, flow rate, or viscosity. No break through is possible even with a complete shut down of the filter. Filtering can be resumed with perfect safety at any time. With Sparkler plate construction a completely sanitary filter can be furnished. A thin, economical precoat is possible with a minimum of filter aid.

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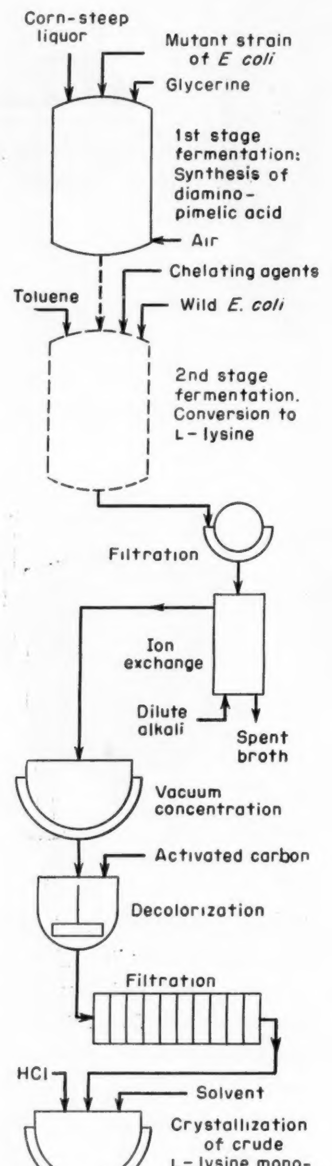
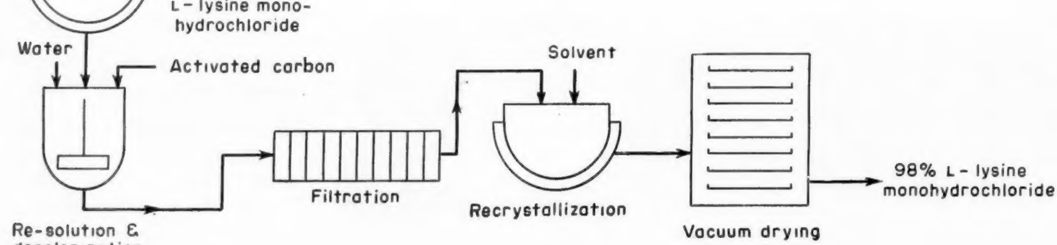
New Process Presages Lysine Surge

Fermentation route, just put into commercial use by Pfizer, joins extraction and chemical synthesis processes in bid for lysine's potentially lucrative markets.





One of the chemical industry's most versatile tandems—Pfizer and fermentation—has bounded into the news again. The reason: First commercial production via fermentation of L-lysine, one of the eight essential amino acids and the one most lacking in wheat products like flour and cereals.

This puts three major companies in a position to produce volume quantities of the levorotatory, or biologically active, isomer of lysine. More than two years ago Du Pont announced a total chemical synthesis from furfural and a pilot plant to back it up. What's more important, you'll probably see Du Pont get a $1.5-million lysine-from-furfural plant rolling this year at Niagara Falls, N. Y.

▶ **Synthesis for the Long Run**—Merck, in lysine production for about six months, will give no clues as to its manufacturing techniques or its future plans. Most of Merck's present output is thought to be via fractionation of animal blood.

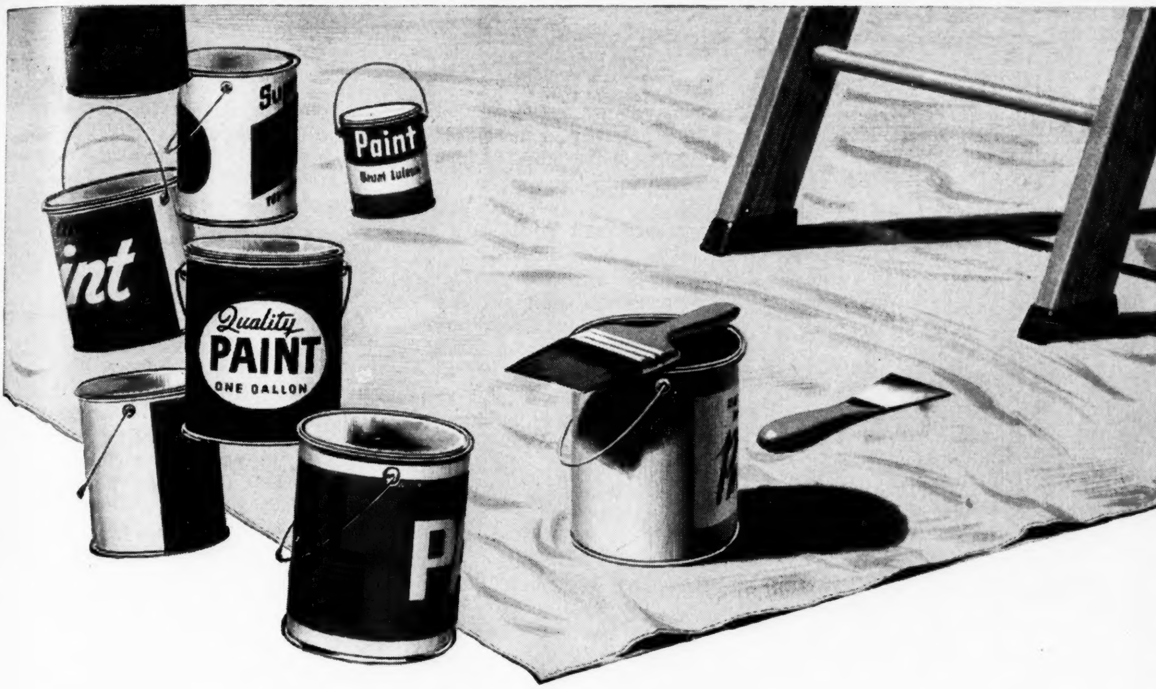
But you should expect Merck to switch to synthesis if markets for lower-priced lysine open up. (Present price for L-lysine is $12/lb. in 50-lb. lots.) That's because recovery of lysine from natural sources is not considered economically attractive, in the long run, for big-volume markets. And you need only review Merck's patents to see how well-grounded the firm is in the area of chemical synthesis of amino acids.

Now, with Pfizer's fermentation technique in the ring—promising to "prepare lysine at a price substantially below that at which the compound is currently sold in commerce"—the plot doth thicken.

▶ **Many Contenders**—Others are working, too, in the lysine field. Dow markets small amounts of DL-lysine; Wilson & Co. will get into L-lysine production from packinghouse wastes; Bios Laboratories synthesizes both DL-lysine and L-lysine; and Department of Agriculture's Northern Regional Research Laboratory in Peoria, Ill., is experimenting with fermentation production of lysine-containing microorganisms.

Du Pont, Merck and Pfizer offer a product whose L-lysine content is 95% or better. Pfizer uses a selective fermentation and microbiological transformation (akin to pinpoint chemistry in steroid modification) to synthesize levo isomer to the virtual exclusion of dextro isomer.

▶ **Half and Half**—Any chemical synthesis, on the other hand, will yield a racemic mixture of lysine isomers, half of which is biologically inactive. Thus, separation and recycling of unwanted D-isomer for subsequent conversion to the levo form are



The proof is piling up!

Isophthalic Based House Paints are Vastly Superior

Exterior house paints based on Isophthalic—

***have** uniform through-dry—no paint wrinkling*
Oronite's extensive testing, plus results by leading resin manufacturers, prove Isophthalic greatly superior to other materials in this regard.

***have** faster drying properties*
The higher, more uniform molecular weights give a dry film — quicker.

***have** practically no yellowing in light tints*
With Isophthalic, oils can be used which greatly reduce the amount of normal paint yellowing.

***have** mildew resistance*
This quality appears to result from less unattached fatty acids present.

***have** outstanding flexibility characteristics*
At longer oil lengths greater flexibility results from higher proportion of flexible fatty acids in the molecule.

***have** better color retention*
Closer bonding of pigment particles give more uniform color appearance after application.

***can be** manufactured at lower cost*
Manufacturing costs can be reduced because more low-cost oils can be used.

Resin and paint manufacturers can now offer new and improved products with Oronite's new, advanced raw material — Isophthalic. Contact any Oronite office for complete information—or ask your resin or paint manufacturer about Isophthalic.

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36, Avenue William-Favre, Geneva, Switzerland
4021

necessary to Du Pont's and Merck's techniques.

At present lysine finds outlets as an ingredient of pharmaceutical products (dietary supplements) and specialty foods. These fields are definitely limited, however, and the triumvirate of big producers is most assuredly looking beyond them in its plans.

Pfizer regards lysine as a chemical which could become as important as some vitamins. At least two things lead you to believe the firm doesn't expect to have to wait five or ten years for things to start breaking: Du Pont's long interest in lysine and its present plans for increased production; and the suspicion that a company like Pfizer wouldn't jump into something like this unless it could see a $1-2-million market for itself in, say, two years.

▶**Not Cut and Dried**—Yet an independent consulting organization concluded from a recent survey that, although lysine could prove to be a bonanza, there's little justification for anyone to go to town with large-volume production for some time.

There's controversy, too, as to the nutritional efficacy of lysine, of amino acids in general. More proof is needed from clinical studies, proof that addition of lysine to foods offers benefits to significant population groups (e.g., children, old people).

Obviously anyone in the lysine business will have to do a superb selling job to put the chemical over. They'll have to sell the government on the nutritional need for, and beneficial effects of, lysine addition. They'll have to sell vitamin formulators and food processers on the competitive advantages of lysine-enriched products. They'll have to get lysine's present price much lower if they are to catch the serious attention of the feed industry (although a less-pure form or a lower dosage might be worthwhile).

The domestic market will be tough to crack. But don't forget the overseas potential. Conceivably, a way might be found, through the United Nations, to move lysine to backward areas with acknowledged nutritional deficiencies. Then, with a substantial volume outlet of lysine shaping up, the domestic producer would be able to shave prices to open up bigger home markets.

▶**Fermentation Route** — Fermentation has proved many times to be a low-cost route to chemicals. Let's examine Pfizer's patented two-stage lysine process, now in operation at the Brooklyn plant:

A mutant strain of *E. coli* is grown, in an aerated, submerged fermentation, on a medium of corn-steep liquor. The pH is held at, or close to, neutrality, and 1-10% glycerine is added gradually to help obtain high yields of α,ϵ-diaminopimelic acid. (Other diaminopimelic isomers don't convert to lysine as predictably or cleanly.) The mutant *E. coli* is unable to convert diaminopimelic acid to lysine, but requires small amounts of lysine (which it obtains from the corn-steep liquor) for growth.

In about three days, when pimelic synthesis has reached a peak, Pfizer adds another microorganism to the brew—a wild, or common, strain of *E. coli* which doesn't need lysine for growth but which does generate the important enzyme, diaminopimelic acid decarboxylase. This enzyme, in turn, decarboxylates the dibasic pimelic acid to yield α,ϵ-diaminocaproic acid, or lysine.

Toluene is added to rupture the *E. coli* cell walls and liberate the enzyme for biosynthesis. It also serves to maintain sterility during process stages when the enzyme is doing its job.

Addition of chelating agents (to regulate concentrations of metallic ions needed by microorganisms) and vitamin B_6 helps obtain maximum conversion of diaminopimelic acid to L-lysine.

▶**Lysine Recovery**—After 24 hours the enzyme reaction mixture is acidified and clarified on a precoated rotary vacuum filter. Filtrate passes through towers of sulfonic ion-exchange resins, where lysine is absorbed and subsequently eluted with dilute alkali. Concentration of the eluate, decolorization with activated carbon and filtration follow.

Addition of hydrochloric acid and a solvent causes L-lysine monohydrochloride to crystallize. Re-solution of the crude salt, carbon treatment and recrystallization from another solvent-water system produces 98% L-lysine.

New Zinc Oxide Process Gets First Plant Use

A new process to make high-grade oxide directly from zinc sulfide ore concentrates without prior roasting (*Chem. Eng.*, Nov. 1954, p. 100) is now in commercial use at a 10-ton/day plant of Northwest Refining & Chemical Co. in Spokane, Wash.

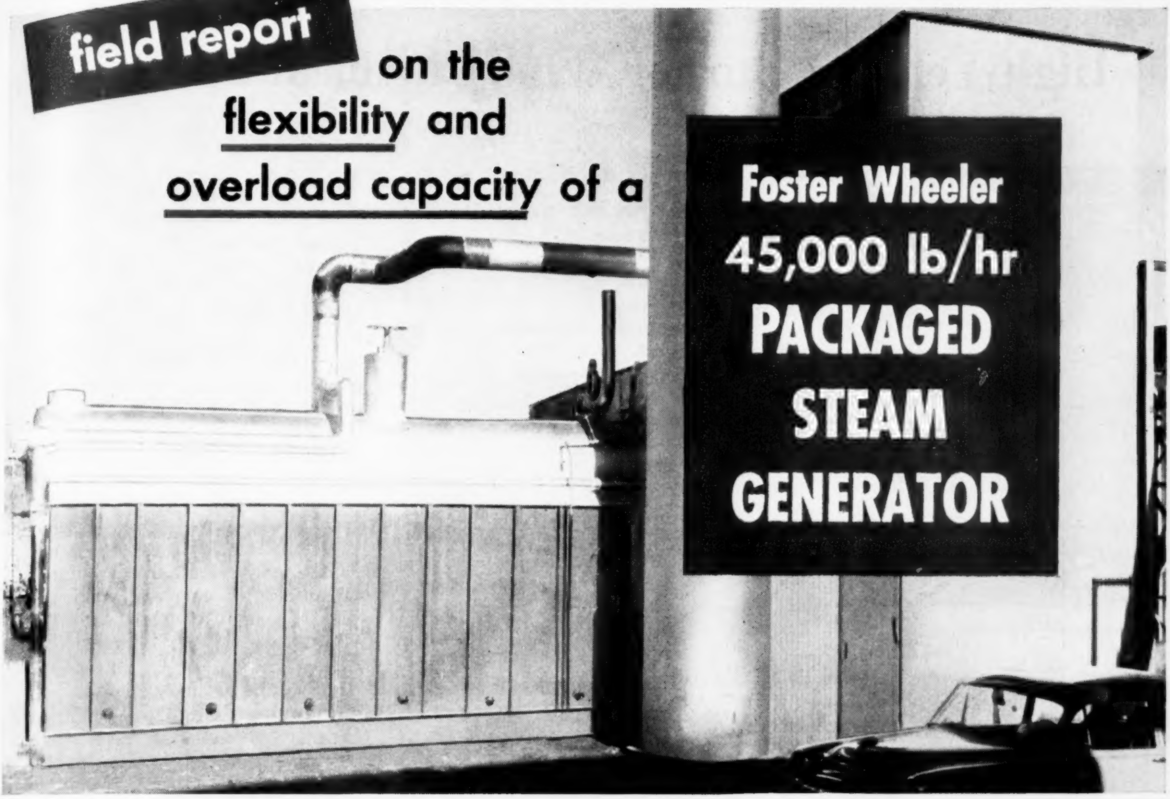
Key piece of equipment—a stationary reverberatory furnace—was developed by Barnard Wilcox, company president. After drying and passage through vibrating screens, ore concentrates go to multiple ignition chambers of the furnace. Flash oxidation of ore in air at 2,600 F. and rapid segregation separates raw materials into slag, metallic oxides and combustion gases.

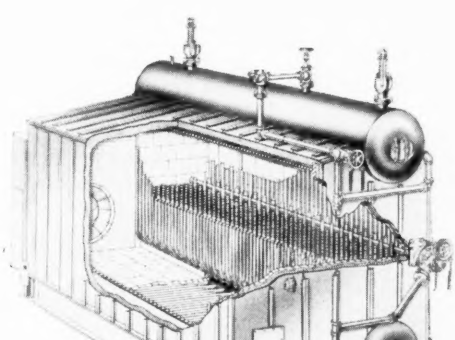
The $250,000 plant produces ammonium sulfate, two types of zinc oxide and zinc ingot. Process can start with either standard concentrates (50-55% zinc) or low-grade flotation concentrates (30-40% zinc).

Independent Service Firms Show Strong Growth

Fluor Corp.'s recent announcement that it will add research to the engineering-construction services it has long offered the chemical process industries reflects the startling wholesale growth enjoyed by independents—in both research and engineering fields—since World War II.

An informal poll at a recent meeting of the American Council of Independent Laboratories, for example, revealed that business of all member companies had grown 20-30% during 1956. Increases during the past five years were estimated at about ten-fold. Most frequently mentioned reason for the growth: Engineer shortage puts manufacturers in need of all the auxiliary help they can muster.





Cutaway drawing of FW Packaged Steam Generator of the type shown installed above at a large New England chemical plant. Except for the firing front, the entire unit is located out of doors. The performance tests mentioned here were made in December, under typical New England weather conditions.

FOSTER WHEELER engineers have conducted extensive performance tests on a 45,000 lb/hr oil-fired Packaged Steam Generator installed at a large New England chemical plant.

During a 30-day period, the unit was operated at 42,500 lb/hr on a 24-hour basis, delivering over 1,000,000 lb of steam per day. It was also operated at 46,500 lb/hr over an 8 hr period.

Efficiency at design load of 45,000 lb/hr exceeded contract requirements of 83.2%. During performance tests the boiler was operated in excess of 51,000 lb/hr at an efficiency of 82%.

Although purchased as a base load unit, tests were also conducted to determine its flexibility. Rapid load swings from 10,000 to 51,000 lb/hr were set up while on automatic control. The boiler was able to swing from one extreme to the other in considerably less than 60 seconds.

This very satisfactory performance stems from the conservative FW design and generous water storage capacity which are important features of the entire standard line. Available in rated capacities from 10,000 to 50,000 lb/hr, with wide choice of burners and controls. For complete information, send for Bulletin No. PG-55-3. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

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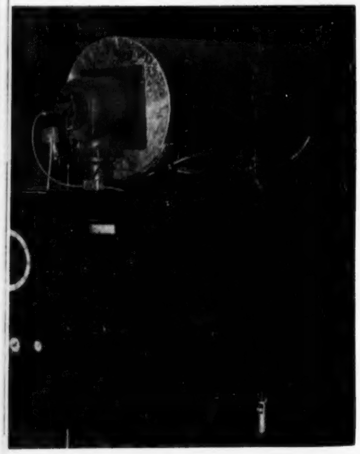
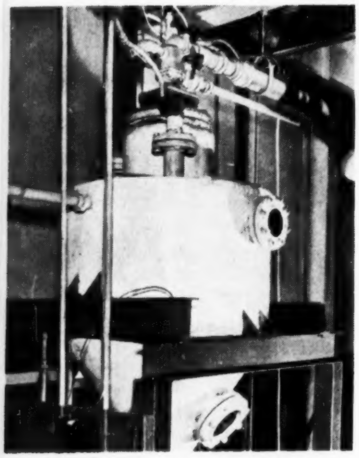
High-Velocity Burner Wins Chemical Spurs



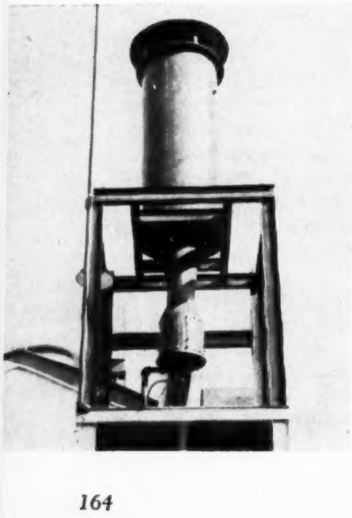
Drying and Heating Applications

Allied Chemical, Hopewell, Va.
Application undisclosed
Dow Chemical, Bay City, Mich.
Heating magnesium melting pots
DuPont, Deepwater, N. J.
Spray-drying dyes, detergents, pigments
Harshaw Chemical, Elyria, Ohio
Spray-drying catalyst pellets
Rubberoid Co., Rochester, N. Y.
Wallboard drying



Submerged Combustion Applications

Barium Products Co., Modesto, Calif.
Heating barium sulfate solution
Callery Chemical, Callery, Pa.
Concentrating, neutralizing waste NaOH
U. S. I. Chemical, Tuscola, Ill.
Concentrating sodium sulfate solution



Waste Disposal Applications

Atomic Energy Commission, Weldon, Mo.
Fume decomposition
Columbia-Southern, New Martinsville, W. Va.
Decomposing phosgene
B. F. Goodrich Chemical, Avon Lake, Ohio
Burning acetic acid-acetone mixture
Quaker Chemical, Conshohocken, Pa.
Burning fumes from wax processing

When Leonard Peskin, president of Thermal Research & Engineering Corp. (Conshohocken, Pa.), dropped into our offices four years ago to tell us about the high-velocity oil and gas burner being developed by his infant company, we asked him what this new burner could do in chemical process applications.

At that time the burner was so new that its value to chemical engineers could be described only in terms of potentialities (see *Chem. Eng.*, Dec. 1952, p. 104, and Feb. 1953, pp. 208-209).

But today we find the chemical process industries turning to the Thermal burner for a steadily growing number of jobs. A sampling of them appears in the list at the left.

▶**Changing Picture** — Direct heating for a wide variety of drying tasks currently dominates the scene. And from the bright impression the burner's scored so far, especially on dryer manufacturers and designers like Wyssmont and General American Transportation, it should continue to do so for some time. Wyssmont's President Arnold Weisselberg predicts that it will be used with most of his company's big Turbo dryers in the future.

But, with the hard search on for more potent routes to waste disposal, the burner seems to be finding still another forte. Outfits like Quaker Chemical, B. F. Goodrich and Columbia-Southern burn completely to innocuous off-gases a surprising diversity of materials—from asphalt to phosgene.

Along somewhat similar lines, the burner is being tried out in the role of a reactor. Stone & Webster, teamed with Thermal, announced in November that it has developed a burner to produce sulfur dioxide from sulfur. And Badger Mfg. Co. recently installed a Thermal unit for the manufacture of sulfur from hydrogen sulfide at Montana Sulfur & Chemical Co., Billings, Mont. Too, the burner is gaining experience in submerged-com-

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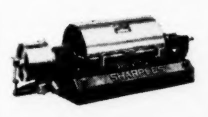
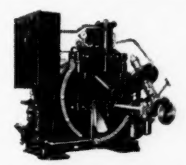


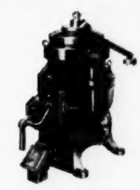
SUPER-D-CANTER

Continuous centrifuge for separation of large amounts of solids from slurries, and for wet classification of solids.



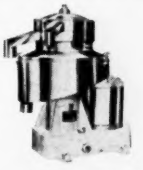
SUPER-D-HYDRATOR

Completely automatic crystal dehydrator with external control of feed, rinse, and drying cycles.



DG-2 AUTOJECTOR

A clarifier or separator which automatically discharges liquids and comparatively dry solids.

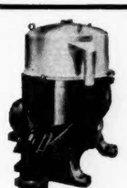


DH-3 NOZLJECTOR

Heavy duty continuous solids discharge clarifier, separator and concentrator for high solids content slurries.

Seven types of Sharples continuous centrifuges—each designed and industry-proved to do a better job in a particular set of circumstances.

. . . and all seven of these Sharples types of centrifuges, including numerous additional variations, stand ready to serve you in the Sharples Process Testing Laboratories—these are full-sized machines capable of running your product under plant conditions.



D-2 CENTRIFUGE

High capacity centrifuge effects clarification of liquids and separation of two immiscible liquids. Continuous liquids discharge.

SUPER CENTRIFUGE

Provides highest centrifugal force of any commercial centrifuge (13,200 x G); clarifies liquids and separates two immiscible liquids.

SUPER CLASSIFIER

A continuous fine dry powder classifier combining high capacity, sharp separations, and high product recovery.

Modern processing needs the *facts* about the savings in continuous centrifuging—Sharples has the full line from which to make an unbiased recommendation—backed up by performance.

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bustion and heating operations —*techniques enjoying growing* attention themselves.

▶ ***Inviting Assets***—*Reasons for* this mounting industry interest in the burner *stem from* its high-speed, short-flame combustion—a characteristic perfected originally for jet and rocket engines. Gases flow at velocities up to 500 ft./sec., flame temperatures hit 3,500 F. And better than 85% of the burning is completed in the burner itself.

Thus the burner gets high rates of heat release in small combustion spaces. As Thermal points out, space-heating rates in the high-velocity burner reach 10 million Btu./(hr.) (cu. ft.), while conventional burners seldom top 100,000 Btu./(hr.) (cu. ft.).

Burner users report that this means to them: smaller furnaces, nearly complete elimination of furnace refractory linings, faster furnace heatup time, sootless gas stream even when burning heavy oil fractions. And these assets, they find, offer economies in operating and installation costs that offset the Thermal burner's greater price.

▶ **On-Stream Payoff**—Wyssmont Co. (Long Island City, N. Y.) illustrates how it exploits these features in its Turbo dryers.

As the heat source for a dryer designed to drive off 2,000 lb. water/hr. from catalyst pellets (for Filtrol Corp., Vernon, Calif.) Wyssmont selected a 3.6-million-Btu./hr. Thermal gas burner. Put on stream in October, it fires into a 35-cu.-ft. air-heating chamber. Weisselberg estimates that a low-velocity burner doing an equivalent job would require a furnace mixing chamber of some 110 cu. ft.

General American Transportation Co. (Louisville, Ky.) reports a comparable space-saving figure with a Thermal oil burner. Using a 4-million-Btu./hr. unit for a rotary dryer to dry ammonium sulfate, GAT estimates it needs about one-fourth of traditional furnace space.

▶ **No Refractory Protection**—In neither of these installations, the firms report, is a refractory lining necessary. This is because of the burner's short flame.

Besides its high initial cost, a refractory furnace lining under *the beating heat and flame of a* conventional burner demands *constant repair and usually* must be replaced after about a *year's service.* Weisselberg places the cost of each replacement alone at $1,000 to $6,000, depending on furnace size. So, while the space-saving feature of the Thermal unit fades out in lower-heat-release units, Wyssmont found it economical to choose a small 500,000-Btu./hr. burner to dry catalyst pellets for Houdry Process Corp. on the basis of refractory savings.

▶ **Direct Drying**—The short-flame feature also reportedly permits drying directly with combustion-product gases. Columbia-Southern Chemical (Barberton, Ohio) put on stream in December a Turbo dryer capitalizing on this advantage. It evaporates 11,000 lb. water/hr. from calcium chloride with 20 Thermal units (total: 19 million Btu./hr.) firing directly into the unit, with trays and structural members expected to stand up without refractory protection.

These features also mark the burner's success in submerged-combustion and heating operations. Equipment size, Thermal reports, have been reduced by as much as 75%. In waste disposal these attractions join with the burner's ability to handle very viscous materials. By bleeding off some of its high heat production, the burner preheats and vaporizes liquid fuels and wastes before they are ignited.

▶ **How Burner Burns** — Fuel enters through a standard pressure atomizer, air passes to an annular space from a low-pressure nozzle in the barrel-like burner assembly. Both streams mix in a vaporizing zone with combustion gases that have been sucked back through an annular recirculation chamber. Here liquid fuel is vaporized, but no burning occurs since the stream velocity is greater than the flame propagation velocity.

Burning starts further downstream at a recessed shoulder flame holder. There a sudden increase in burner diameter drops the mixture velocity sufficiently. Too, the low pressure *at this point pulls back some of* the hot combustion gases *through the annular space to* vaporize the liquid fuel.

Initial ignition is accomplished with an electric spark, but the recirculating combustion gases heat the incoming fuel and air sufficiently to allow self combustion once burning starts.

Convention Calendar

Society of the Plastics Industry, twelfth annual technical and management conference, reinforced plastics division, Edgewater Beach Hotel, Chicago, Feb. 5-7.

Chemical Market Research Assn., "Our Next Five Years of Competition with Foreign Chemical Industry," Sheraton Hotel, Philadelphia, Feb. 19-20.

American Society for Quality Control, Rochester section, 13th annual quality control clinic, War Memorial, Rochester, N. Y., Feb. 19.

National Society of Professional Engineers, spring meeting, Hotel Francis Marion, Charleston, S. C., Feb. 15-16.

American Society of Heating and Air-Conditioning Engineers, 13th International Heating & Air-Conditioning Exposition, International Amphitheatre, Chicago, Feb. 21-Mar. 1.

American Institute of Chemical Engineers, national meeting, Greenbrier Hotel, White Sulphur Springs, Va., Mar. 3-6.

National Assn. of Corrosion Engineers, 13th annual conference and exhibition, Kiel Auditorium, St. Louis, Mo., Mar. 11-15.

1957 Nuclear Congress; consists of second nuclear engineering and science congress, 5th atomic energy in industry conference, international atomic exposition, hot laboratories committee's 5th hot laboratories and equipment conference; Convention Hall, Philadelphia, Mar. 11-15.

a reactor of gold for hot atoms

This Nooter expert is welding a solid gold liner for an experimental reactor to be used by the Los Alamos Scientific Laboratory.

From the resulting tests, the Atomic Energy Commission hopes to gather enough data to make possible the design of a portable power source for future military outposts.

The fabrication and weldment of pure gold on such a large scale is probably without precedent, but Nooter has been in training for difficult pure metal and alloy fabrication jobs for many years.

The Nooter Research Laboratory has pioneered and improved welding techniques on many metals. To you, this means better processing equipment, in the pure metal or alloy most suitable to your needs.

Your next tank or vessel job may not be as unusual as the reactor shown here, but you can be sure of one thing—it will receive the same care and attention to detail given to every Nooter assignment. May we serve you soon?

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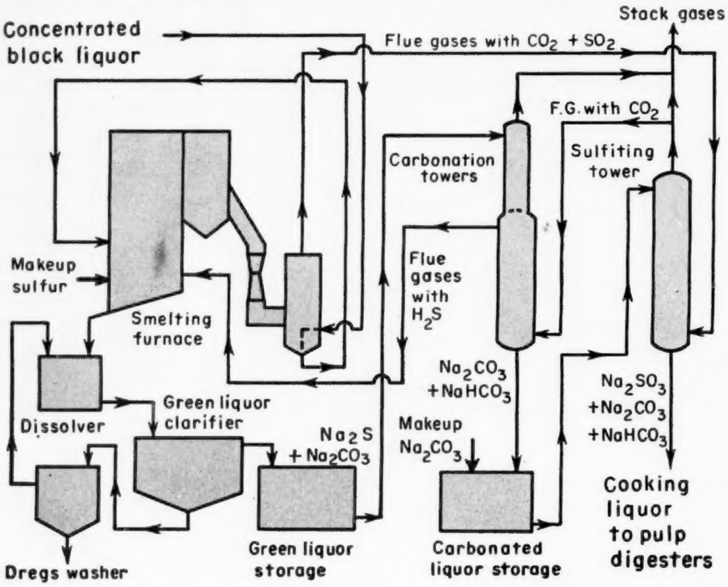
How Mead Process Recovers NSSC Pulping Chemicals



One Answer to Two Problems

Mead process avoids stream pollution, recovers NSSC pulping chemicals. Two-stage carbonation, recycle of H_2S to recovery furnace are key steps.

Any process which offers a solution to the problems of raw material recovery and stream-pollution abatement is always good news to semichemical pulp producers. That's why they're eyeing with interest the commercial unveiling of the Mead recovery process at two neutral sulfite semichemical (NSSC) plants—Watervliet Paper Co., Watervliet, Mich. (on stream about now), and Mead Corp.'s Heald Div. plant at Lynchburg, Va. (on stream later this year).

The new process, developed and pilot-planted by Mead in collaboration with Babcock and Wilcox, not only promises to reduce river pollution, but also claims up to 97% sodium recovery and 92% sulfur recovery.

▶**Now It Can Be Told**—The pulp and paper industry has long been aware of Mead's activity in this field, but little has been publicly known as to how the proposed process worked. Now that patent claims have been allowed, Mead and B&W disclosed the elements of the process in November at the Alkaline Pulping Conference of TAPPI in New Orleans.

Basically, the Mead process involves conversion of a "green liquor," made from a furnace smelt containing sodium sulfide, into a neutral sodium sulfite cooking liquor, via two-stage carbonation and sulfiting with furnace flue gases (*see flowsheet*). The hydrogen sulfide evolved during carbonation is returned to the furnace for burning to sulfur dioxide.

▶**Here's the Problem**—Spent NSSC liquor, like black liquor from the kraft pulping process, can be readily concentrated in multiple-effect evaporators (not so with lime-base acid sulfite liquor) and burned in a "smelting" furnace. In the furnace, organic matter is burned off and the inorganics are discharged as a smelt of sodium sulfide and sodium carbonate.

Whereas the kraft process reuses the sodium sulfide as such, the NSSC process requires sodium sulfite. Any NSSC scheme which recovers the sulfur values, therefore, must incorporate an oxidation step somewhere. This is easier than it first seems, as testified to by the number of attempts at developing a successful process.

A neat way around the difficulty is to operate a NSSC mill in conjunction with a kraft mill, and several pulpers do just that. However, the kraft mill must be much larger (about three times) than the NSSC mill in order to absorb the NSSC waste liquor.

▶**Some Possible Answers**—The Mead process is by no means the only one which has been under investigation. Both here and abroad a number of recovery systems have been studied in laboratory, pilot-plant or full-scale operations. Some of these are:

- Institute of Paper Chemistry process, which makes no attempt at sulfur recovery, treating green liquor with complete makeup SO_2. This process is the only one, other than the Mead, in commercial use in the U. S.
- Zimmermann process, whose chief objective is disposal of organic wastes rather than chemical recovery (see *Chem. Eng.*, Dec. 1955, pp. 103-4). Sodium values, but not sulfur values, can be recovered from the aqueous effluent.
- Sulfox process, in which smelt is oxidized with air to recover both soda and sulfur.
- Sivola process, recovering both soda and sulfur, in which H_2S released by carbonation is sent to the sulfur burner and burned with makeup sulfur.
- Stora Kopparbergs process, in which part of the H_2S released by carbonation is reacted with bisulfite solution to form thiosulfate. The thiosulfate solution is recycled to the evaporator (see *Chem. Eng.*, Dec. 1955, pp. 134-8).
- Rayonier process, in which ion exchange resins are used to remove sulfide ions, which are then released as H_2S and burned to recover SO_2 (most soda is lost).

(*Continued*)

▶**Black Liquor to Green**—In somewhat more detail, here's how the Mead process works:

Spent black liquor is washed from the pulp, concentrated in multiple-effect evaporators and further concentrated in a venturi scrubber. (The scrubber also serves to avoid fume nuisance in the plant vicinity and reduce contamination of sulfited liquor with sodium sulfate fume and fine carbon carryover.) Concentrated liquor is then burned in a kraft-type recovery furnace.

The resulting ash, or smelt, containing sodium sulfide and sodium carbonate, is dissolved in a conventional green-liquor dissolving tank. Green liquor is clarified in a single-compartment clarifier, with the usual dregs washer. And weak wash returns to the dissolving tanks as makeup water. A large green-liquor storage tank permits suspension of carbonation system operation, when desired, without disturbing the rest of the system.

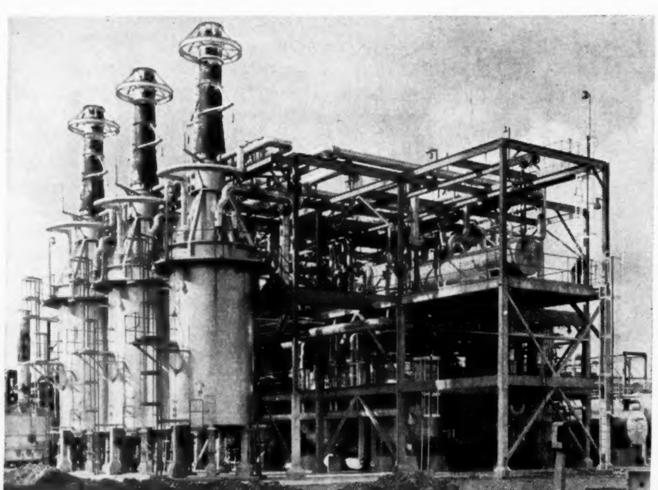
▶**First Carbonation**—Clarified liquor flows from the storage tank to the top of a precarbonation tower, where it's contacted by about one-third the total carbonation tower system gas flow. This gas contains hydrogen sulfide when it enters the system. But after scrubbing by incoming green liquor, its H_2S content is reabsorbed. And it discharges as an H_2S-free flue gas.

Partially carbonated green liquor exiting from the bottom of the precarbonation tower has this composition: It contains absorbed H_2S (to the extent that all the sodium sulfide present in incoming green liquor has been converted to sodium hydrosulfide) plus a sizable quantity of absorbed carbon dioxide (with consequent conversion of some sodium carbonate to sodium bicarbonate). Under these conditions, the liquor attains its maximum H_2S vapor pressure. And at this point the flue gas, containing a maximum H_2S content—5% by volume—is taken off and returned to the furnace.

▶**Final Carbonation** — Next, partially carbonated green liquor flows to the main carbonation system, countercurrent to the flow of about 25% of the flue gas resulting from combustion. Here liquor absorbs CO_2 and releases H_2S; gas gives up CO_2 and takes on H_2S.

As in the case of the green-liquor storage tank, a carbonation liquor storage tank is provided to permit out-of-phase operation of towers and furnace.

Finally, in a packed sulfiting tower, all furnace flue gases are scrubbed with carbonated liquor to recover SO_2, which is transformed to sodium sulfite. Liquor exiting from the tower can then be used for cooking purposes.



New Expansion Makes U.K. Self-Sufficient in Styrene

With a new major extension to its styrene monomer plant at Grangemouth, Scotland, Forth Chemicals Ltd. believes that it will now be possible to satisfy all British industry's present needs for the product without having to rely on any further imports from the dollar area. New units more than double the company's capacity, bring total output to 30,000 tons/yr.

News Briefs

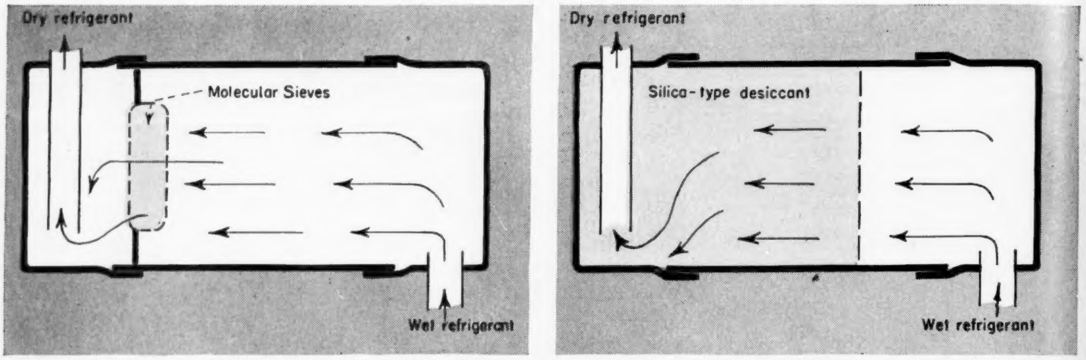
Irradiated rubber: Goodyear Tire and Rubber has opened a $125,000 radiation laboratory in Akron, said to be the first of its kind in the rubber industry. Cobalt-60 will be used as radiation source.

Amino acids: Dow Chemical has started a $500,000 pilot plant capable of producing all eighteen of the amino acids now sold by the company.

Electric furnace materials: Norton Co. has completed a plant at Huntsville, Ala., to manufacture a variety of electric furnace materials, including boron carbide, fused zirconia, fused magnesium oxide and fused alumina.

Epoxies: Shell Chemical has completed two new epoxy resin units at its Houston plant which triple production there.

Phosphate fertilizer: Coastal Chemical Corp. will complete a $2-million integrated phosphate fertilizer plant in Pascagoula, Miss., by early 1958. To include a 75-ton/day phosphoric acid unit and a 350-ton/day granulated ammonium phosphate fertilizer unit, the plant will be the first in the U.S. to use the St. Gobain process developed in France.



ONE cu. in. of Molecular Sieves in automobile air conditioner replaces TEN cu. in. of silica-type desiccant.

New Desiccants Enter Refrigerant Field

Selective adsorbents have up to 19 times usual capacity for drying refrigerants.

Just two years have passed since Linde Air Products introduced Molecular Sieves, synthetic zeolites which adsorb or reject materials on the basis of molecular size. And in that time, a great deal of interest has been evinced in these selective adsorbents for a wide variety of uses ranging from hydrocarbons separation to drying and purification of gases and liquids.

One obvious application of the new desiccants—and one which has already proved successful in laboratory and field tests—is that of drying refrigerants.

On the basis of results reported by both Linde and three manufacturers of refrigeration and air-conditioning equipment, Molecular Sieves Type 4A seem far and away the most effective drying agents of popular refrigerants (chlorinated and fluorinated hydrocarbons), with up to 19 times the capacity of the best of silica-type adsorbents.

A rundown of their more important advantages shows why manufacturers are capitalizing on Molecular Sieves:

- High water capacity at refrigeration unit temperatures as high as 140 F. and at water concentrations as low as 10 ppm. Residual water concentration can be reduced to 2 ppm. or less. Small pores in the crystalline structure of Molecular Sieves exclude both refrigerant and oil molecules from the adsorption surface. Thus the entire adsorbent volume is used only for water.
- Improved equipment design—Because Molecular Sieves have a much greater adsorptive capacity than silica-type desiccants, drier manufacturers can offer smaller drier cartridges — economically advantageous where space is of critical importance, e.g., in automobile air conditioners.
- Increased capacity of drying cartridges.
- Complete removal of acids by coadsorption with water.
- No catalytic breakdown of refrigerants.

Though refrigerant drying is by no means the major application for Molecular Sieves (petroleum and chemical processing are the potential leaders), Linde looks to getting its fair share of this better than a million-lb./yr. market. Price of MS Type 4A is $1.95 in all quantities.—**Linde Air Products Co., 30 E. 42nd St., New York 17, N. Y.** 174A

Lignin-Based Surfactant

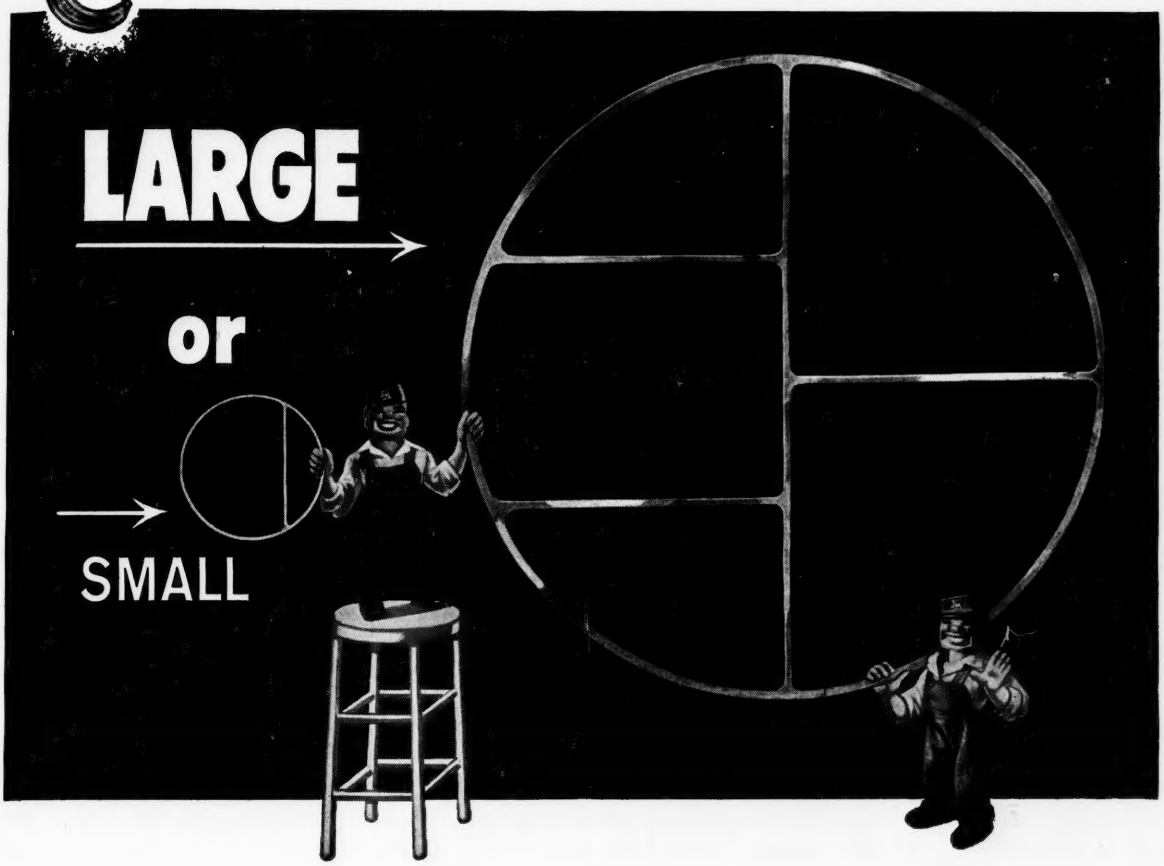
Precipitates readily from dilute and concentrated solutions.

Latest addition to the Orzan family of silvichemicals manufactured by Crown Zellerbach is Orzan P, a surface-active, lignin sulfonate.

Like other Orzans, the new compound is derived from spent liquor resulting from the manufacture of paper via the sulfite process. And like other lignin sulfonates, it has outstanding ability to disperse particles in water and hold them in suspension.

Orzan P does, however, have this added advantage over other lignin sulfonates: It precipitates readily from solution and clings to fibers or other materials. It may be precipitated from even dilute solutions by

Hand-tailored to any size you need...



...Goetze Heat Exchanger Gaskets are precision-made for longer service

Whether your requirements call for heat exchanger gaskets larger than 100″ in diameter, or smaller than 10″, you can get the exact size you want ... hand-tailored to the shape you need ... simply by specifying "Johns-Manville Goetze."

And because they're *precision-made,* you'll find these better gaskets provide the effective sealing and longer life that make them actually cost less in the long run. Each gasket is carefully constructed in every detail to assure accuracy of fit ... to provide ample lap widths and uniform rib widths ... and to prevent trouble-making wrinkles or cracks on the corners.

If you're having trouble with persistent joint leakage and frequent gasket replacements, find out how little it costs to have Goetze Heat Exchanger Gaskets tailored to your requirements. Your blueprint or template will bring a prompt estimate. Address Johns-Manville, Box 14, New York 16, New York.

Johns-Manville *Goetze* GASKETS

THERE'S A JOHNS-MANVILLE PACKING AND GASKET FOR EVERY SERVICE

Newsworthy chemicals this month

Page number is also Reader Service code number

For more about any item, use Reader Service Card

addition of alum. Recommended uses: binder for fibers, retention of fines, emulsifier, emulsion stabilizer, flocculant and dispersant.

In addition to Orzan P, CZ is marketing five other types which have so far found markets as stabilizers, binders, emulsifiers, flocculants, wetting agents, ore flotation reagents, sequestering agents.

Promising future applications are envisioned in the field of agriculture—to improve soil structure, water penetration and growth of certain crops; supply added nutrients to the soil; minimize wind corrosion. —**Crown Zellerbach Corp., 343 Sansome St., San Francisco, Calif.** **174B**

Paint Remover

Nonflammable, for Epon- and epoxy-based paints.

LPO (Lifts Paint Off) is a nonflammable paint remover designed to handle difficult removal jobs. It will blister Epon- and epoxy-based paints off surfaces—often in less than five minutes—without damage to the underlying wood or metal.

Application is simple. LPO needn't be heated to do its work. Just spray or brush on the surface from which paint, varnish, enamel or lacquer is to be removed. When paint has completely blistered, it can be flushed off with a high-velocity stream of water, lifted off with a putty knife or wiped off with a soft cloth. And the surface from which paint has been removed need only be washed with water and dried before repainting.

LPO is available in two forms —one, a standard heavy-bodied material which clings to vertical surfaces; the other, an unthickened material designed for use in tanks.—**RPO Chemical Corp., 2727 E. Nine Mile Rd., Hazel Park, Mich.** **176A**

Acetal Resin

Withstands high temperature, humidity.

An excellent combination of high tensile strength, toughness, high melting temperature, fatigue life, dimensional stability, solvent resistance and resistance to deformation are claimed for a new formaldehyde-based acetal resin developed by Du Pont. Though still in the development stage, success of current pilot-plant production and field research would lead to commercial production by 1959.

Called Delrin, the polymer is similar in probable uses to the company's line of Zytel nylon resins. These uses include aerosol bottles, gears, telephone hand sets, pipe, housewares, automobile parts and wire coatings.

Laboratory and practical tests on Delrin products show that the new plastic retains its properties under conditions of high temperatures and humidity, during an extended time under stress or on exposure to most solvents.—**E. I. du Pont de Nemours & Co., Wilmington 98, Del.** **176B**

Paper Coating

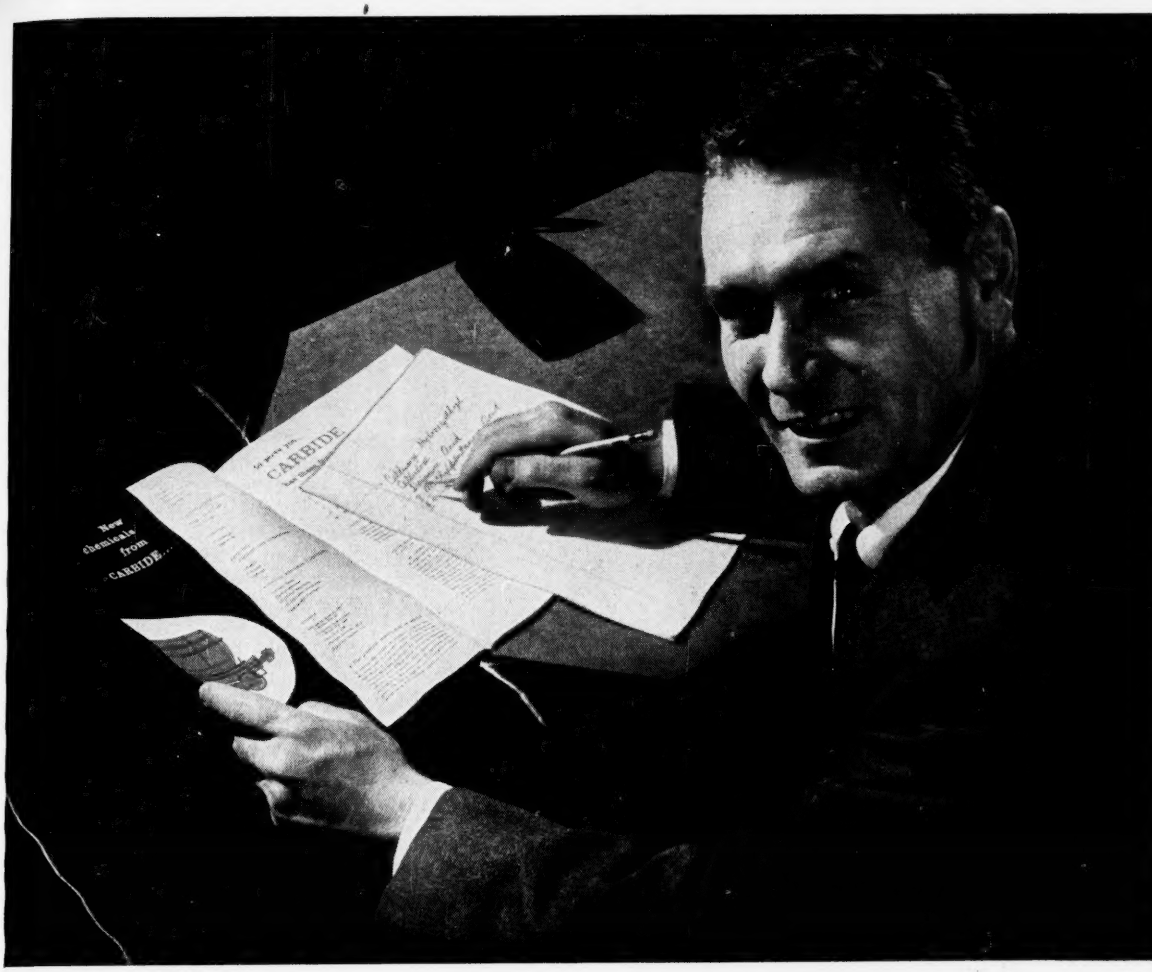
A fortified styrene-butadiene copolymer latex.

Dylex latex K-52 is a new latex designed specifically for use in coating of printed papers. A styrene-butadiene copolymer fortified during polymerization with an added ingredient, the latex owes much of its improved properties to its fine particle size (as compared with other high-styrene types of latexes).

Here's what K-52 offers to paper makers:

- Excellent compatibility with starch, dextrin and protein adhesives commonly used in the paper industry.
- Can be used in paper coating either alone or in combination with natural adhesives and clays to improve printability and ease coating problems.
- Excellent pigment binding strength.
- Produces coating colors with good adhesion and flow properties.

Dylex K-52 has already been field-tested on conventional and off-machine coaters with these



New chemicals = new opportunities

Now's the time to start your study of the 21 chemicals newly available *from Carbide and Carbon. If you are interested in product improvement or developing profitable new products check these chemicals, for instance:*

CELLOSIZE HYDROXYETHYL CELLULOSE WP-4400— an outstanding thickening and stabilizing agent for all types of latex paints; for cosmetics, pharmaceuticals, and textile specialties.

DECANOIC ACID— for preparing paint dryers with improved hydrocarbon solubility; barium salt as a stabilizer for vinyl chloride resins; as an intermediate for plasticizers and lubricants.

2-METHYLPENTANOIC ACID— for the production of diester lubricants, plasticizers, non-yellowing alkyd resins, flavoring.

MORE INFORMATION AND OTHER CHEMICALS

There are many more new chemicals available. Twenty-one are featured in the 1957 edition of "Physical Properties of Carbide and Carbon Chemicals." This quick and easy reference contains the latest physical property and condensed application data for more than 335 organic chemicals.

• • •

Call or write the nearest CARBIDE office for your copy. Ask for F-6136. In Canada: Carbide Chemicals Company, Division of Union Carbide Canada Limited, Montreal and Toronto.

CARBIDE AND CARBON CHEMICALS

Carbide and Carbon Chemicals Company
A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

The term "Cellosize" is a registered trademark of Union Carbide and Carbon Corporation.

results: Coatings have been typified by ease of preparation and fine quality in finished paper—i.e., high gloss, fine printability, fast bond of coating to paper stock, smoothness, excellent wet rub resistance, good light stability.

The fortified latex is available either in 55-gal., nonreturnable drums or in tank car and tank truck lots.—**Koppers Co., Inc., Pittsburgh 19, Pa.** **176C**

Dense Polyethylene

Boilable, stiffer and less permeable than conventional product.

Now on the market in commercial quantity is high-density polyethylene for film, Poly-Eth Hi-D 2504. It is the product of Spencer Chemical's facilities in Kansas City, Mo., which are pioneering commercial use of a high-pressure process to turn out high-density material (*Chem. Eng.*, Nov. 1956, p. 142).

Available at 47¢/lb., the new film's superior properties promise widening markets for polyethylene: Increased heat resistance will permit packaging of foodstuffs for freezing and subsequent boiling before serving; greater stiffness possibly could lead to polyethylene's use on conventional overwrap packaging equipment.

Down-the-line comparison of Poly-Eth Hi-D 2504 (density, 0.938) vs. conventional product (density, 0.915) runs as follows:

- Heat resistance—Visibly unaffected by boiling water where conventional film fails.
- Slip characteristics—Far superior to unlubricated conventional polyethylenes, similar to medium-lubricated conventional resins.
- Stiffness — Two and one-half times stiffer, it handles easier in packaging equipment which suggests possible overwrap applications.
- Permeability — More than twice as impermeable.
- Greaseproofness — Three times better.
- Appearance — Compares favorably with the highest-clarity conventional films and has a sparkling, glossy sheen not apparent in conventional films.

—**Spencer Chemical Co., 610 Dwight Bldg., Kansas City 5, Mo.** **178A**

Silicone Film Treatment

Silicone fluid fills film scratches, makes for better 35-mm. enlargements.

No, the lady above doesn't have a split personality. The left side of her face represents an enlargement made from a scratched 35-mm. negative. The right side, an enlargement made from the same negative, shows how film scratches are eliminated via a new treatment developed at General Electric Co.

Basis of the new process is a silicone liquid called Refractasil and a special negative holder, Refractamatic 35. Together both products solve the problem of scratches (in the film base or gelatin overcoat), dust and oily fingerprints on negatives that would otherwise produce quality prints.

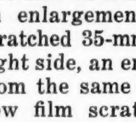
Refractasil meets all the requirements of a scratch-filling material. It has the same index of refraction as the film base. Thus scratches can be filled without bending light rays at the film-liquid interface. (Such light scattering through the negative results in unexposed lines on the enlarging paper or white lines on the finished enlargement.)

The liquid is also water-white, nontoxic, inert to film and emulsion, odorless, of proper viscosity and vapor pressure—neither so high as to vaporize rapidly when used, nor so low as to evaporate promptly when wiped off after use. Too, Refractasil has the added bonus of being easily wiped off, leaving a negative which is both dry and clean. It removes oily fingerprints, and in the special Refractamatic 35 film holder, gets rid of dust.

Used in combination, the silicone fluid and negative holder reduce precautions that traditionally surround handling of 35-mm. film. Any handling procedure that doesn't actually gouge the silver layer can be tolerated.

Both products are being marketed by Simmons Bros. of Long Island City, N. Y.—**General Electric Co., Research Laboratory, Schenectady, N. Y.** **178B**

For More Information...



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.

Reactor Lubricant

Molybdenum disulfide protects control mechanism in atomic reactors.

Given: 60 control mechanisms operating uranium rods in an atomic reactor.

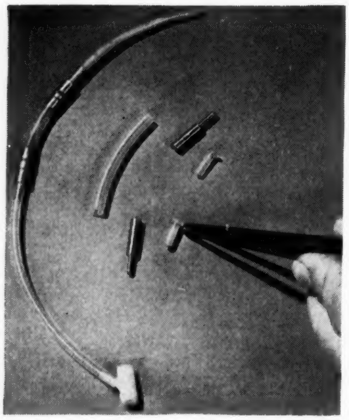
To find: A lubricant which will service these mechanisms yet withstand attack from nuclear radiation and high-pressure, high-temperature, CO_2 atmospheres.

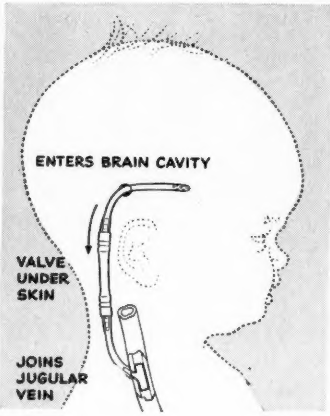
Faced with the above problem, Rocol, Ltd. has developed a varnish producing a MoS_2 film which, via dry treatment, lubricates control mechanisms at Calder Hall Atomic Power Station (England).

Because the new film, Molytox, not only lubricates but also protects the mechanism from corrosion by CO_2, heat and humidity, it's also being used to treat replacement equipment and to pretreat control equipment to be stored.

For special conditions (e.g., emergency or pretreatment of

surfaces which may have to be exposed to abnormal conditions of moisture and corrosion), a reactor fluid based on a MoS_2-containing silicone varnish has been developed. In principle, it's identical with Molytox. But the presence of a water-repellent silicone gives it an added protective feature.—**Rocol, Ltd., Rocol House, Swillington, Leeds, England.** 178C





Silicone Rubber Aids Medical Science

Automatic brain valve offers most promising cure for water on the brain.

A father's desperation and ingenuity plus a new silicone rubber have given birth to an automatic brain valve which is the most promising cure yet developed for hydrocephalus (water on the brain).

Not only has the valve saved inventor John Holter's baby son from certain death, but it has also proved 82% successful in over 80 hydrocephalus cases. (Hydrocephalus annually claims 10,000-15,000 lives—mostly babies'—in the U. S.)

Key material in the new valve design is Silastic S-9711, a silicone rubber developed by Dow Corning. S-9711 is soft, resilient, translucent, nontoxic. But more important, it doesn't have the drawback of conventional plastic brain valves: They're difficult to sterilize; their complex mechanisms easily go out of adjustment; body tissue almost always builds up sooner or later and shuts valves off.

Instead of steel springs or sapphire ball-checks in an acrylic housing, the new valve consists of two side-slit directional nipples—accurate to 0.0003 in.—inside stainless steel cases. Connected with a silicone rubber housing, the nipples open at the slightest input pressure, but provide a double seal against fatal backflow of blood. Thus, the system can drain into the jugular vein instead of the stomach, greatly easing installation. And the double valve gives the assembly a pump action which can be checked by hand for accuracy and functioning.—**Dow Corning Corp., Midland, Mich.** 180A

Metal Substitute

Made from beech-tree veneer and synthetic resin.

Steel, bronze and cast material are soon to be replaced in Rumania by a new ersatz material, Lignomet — a composite product containing white beech-tree veneer and synthetic resin.

The new material, made into solid blocks via a high-temperature, high-pressure laminating process, has already been successfully tested in engine manufacture. It's said to be:

• 40-50% cheaper than bronze.

• 20-30% cheaper than steel or machined cast iron parts. One cubic meter (35.31 cu. ft.) of white beech material replaces one metric ton of metal.

Rumanian sources state that with the production of Lignomet import of parts (e.g., cogwheels) will decrease rapidly and later will be completely halted. — **Magura Codlei, Zeidem, Rumania.** 180B

Fungicide

Equally effective in agricultural and nonagricultural applications.

N-trichloromethylthiotetrahydrophthalimide, originally developed by Esso Research & Engineering Co. to protect farm crops from diseases, is now being used in a number of nonfarm applications including paints, plastics and pharmaceuticals.

As an agricultural formulation, the phthalimide controls and prevents fungi-caused diseases afflicting apples, avocados, carrots, celery, cherries, peppers, potatoes, tomatoes.

And the same properties which account for its success in crop treatment make it look equally promising in these nonagricultural applications:

• Paints—About a tablespoon per gallon (or 1% by weight) protects paint from mold or mildew. And because it's nonvolatile, the phthalimide doesn't wash away or evaporate. Thus, it's said to give paints a high degree of permanence.

• Plastics—Unlike some vegetable-type plasticizers which make vinyl film flexible but susceptible to fungi, the phthalimide makes film both mold resistant and flexible at low temperatures. Its bacterial action makes it particularly suited to vinyl tape used in wrapping and

protecting oil and natural gas pipelines exposed to moist underground conditions.

- Lacquers—When used in lacquer for coating wiring in radio and related equipment, the phthalimide prevents mildew—a major cause of short circuits.
- Pharmaceuticals — In a purified form, the phthalimide has been incorporated in a dandruff remover.

For farm use, the fungicide is known as Orthocide, and distributed by California-Spray Chemical Corp. (Richmond, Calif.). In nonfarm applications, it's known as Vancide 89 and marketed by R. T. Vanderbilt Co. of New York.—**Esso Research & Engineering Co., 15 W. 51st St., New York 19, N. Y.** **180C**

Evaporation Barriers

Cut vapor losses by as much as 75%.

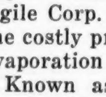
With the introduction of its new evaporation barriers—specially designed for up to 75% vapor retardation — American Agile Corp. offers a solution to the costly problem of industrial evaporation losses.

Known as Agile Mini-Vaps, the barriers are expanded polyethylene miniature floats containing thousands of tiny air cells for buoyancy and light weight. And their specially engineered surface contours provide for extensive interlocking and clustering at the surface of volatile solutions.

In addition to exhibiting outstanding chemical and solvent resistance, Mini-Vaps cannot be punctured or broken.

Suggested applications include plating tanks, fermentation tanks, paper mills, textile dye and solution tanks, solvent and oil storage.

For More Information...



about any item in this department, circle its code number on the Reader Service Postcard inside the back cover.

Prices range from $4/lb. down to $2.90/lb. in lots of 1-100 lb. and over.—**American Agile Corp., P. O. Box 168, Bedford, Ohio.** **182A**

BRIEFS

Rubber accelerator, N-acetyl DL-homocysteine thiolactone, may aid in vulcanization by introducing the highly reactive sulfhydryl group. It may also provide stabilization by forming crosslinking through disulfide bonds at low temperatures and mildly alkaline conditions.—**Schwarz Laboratories, Inc., Mt. Vernon, N. Y.** **182B**

Textile softeners, tradenamed Syl-Soft 10 and Syl-Soft 12, are water-dilutable emulsions of reactive silicone fluids. As little as 1-2% emulsion is needed to give processed fabrics a softer hand, improved tear resistance and sewability. Emulsions are nonionic; they may be used alone or as ingredients in resin finishing baths. — **Dow Corning Corp., Midland, Mich.** **182C**

Vapor barrier coating, VB Coating, is a vinyl resin solution guaranteed to retard rate of vapor transmission to not more than 0.3 grain/sq. ft./hr. (1-in.-Hg vapor differential at 80 F.) through any building material. It's particularly useful in areas requiring humidity control—e.g., pumping stations, warehouses, electronic processing and storage. VB Coating is weather resistant; easily applied to brick, concrete, block, tile; comes in satin aluminum and a wide range of colors.—**Ellis & Watts, Inc., P. O. Box 33, Cincinnati 36, Ohio.** **182D**

Fireproof paper that's self-extinguishing is now possible using Synco 85 impregnating resin. On continued exposure to direct flame, papers char at point of contact; there's no "after glow" or "punking." Papers also exhibit strength, heat and chemical resistance characteristics of phenolic-impregnated materials. Resistance to water immersion or outdoor exposure is obtained by application of a light size coat. Potential uses for Synco-impregnated papers: air filters (where filtering ability is maintained after repreated exposure to direct flame), insulation, structural materials (e.g., honeycomb cores, overlays, laminates).—**Synco Resins, Inc., Bethel, Conn.** **182E**

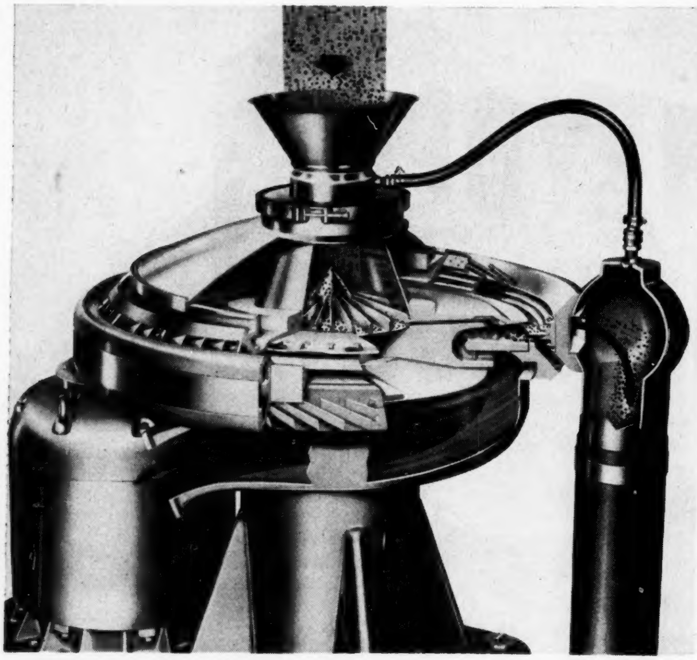
High-safety chlorinated solvent, reagent grade 1,1,1-trichloroethane, makes an ideal substitute for chloroform or carbon tetrachloride in dithizone tests for metals because toxicologists rate it as one of the least toxic of chlorinated solvents. It also serves as a general purpose cold degreaser, acting with the speed of carbon tet, but with far greater safety. Too, all common metals, including aluminum, can be cleaned with the new solvent with relative safety from corrosion. Price: $2/qt., $7.90/gal. —**Fisher Scientific Co., Fisher Bldg., Pittsburgh 19, Pa.** **182F**

Two leather-tanning chemicals —Zircotan S (a sodium zirconium silicate) and Leukanol C (condensed phenolic syntan)—have been developed for use in production of white-tanned leather. Combination of the new materials in the tanning formulation make for a finished leather with improved temper, tighter break and brighter white.—**Rohm & Haas Co., Philadelphia 5, Pa.** **182G**

Lysine, described as one of eight amino acids considered essential to human nutrition, is now commercially available in the form of L-lysine monohydrochloride. Product, made via a fermentation process, is a fine white crystalline material free from D-lysine (isomer that's not used by the body), and with a guaranteed potency of not less than 98%. Under present price schedules, it will sell for $11 per lb. in 50-lb. lots, $14 per lb. in 1-lb. lots.—**Chas. Pfizer & Co., Brooklyn 6, N. Y.** **182H**

PROCESS EQUIPMENT

EDITED BY C. S. CRONAN



New Classifier Boosts Yield

Unit for dry powders is first to combine sharp cutpoint, high efficiency and high capacity. Results are not affected by changes in feed rate or particle size.

Latest product of Sharples Corporation's, 10-yr.-old research and development effort on fine powder technology is the optimum air-vortex Super Classifier. Handling a broad range of dry powders, this new machine fractionates solids by particle size with hitherto unattainable efficiency.

▶**More and Better**—When you ask a Sharples engineer where the Super Classifier excels, he points to separation of maximum product yield at precisely the desired cutpoint.

Fine fractions with top size in the 15-20-micron range will contain less than 0.01-0.04% + 325 mesh particles. Product recovery or yield varies from 80% to well over 90%, depending upon density of the powder and end-use requirements for the product.

Since the Super Classifier recovers such a high proportion of the fine fraction, it greatly reduces the circulating load on existing grinder systems. Thereby, product output is raised without increasing grinder capacity.

Particles can be classified effectively over a range that varies somewhat between limits of 10 and 125 microns, depending upon the specific gravity of the material. Within this range, there is choice of four machine sizes to handle throughputs from 1,000 to 30,000 lb./hr.

Yet, for a given throughput rating the Super Classifier is surprisingly small. Unit with a nominal rating of 10,000 lb./hr. occupies about the same space as an office desk.

▶**Freedom of Action**—Forces within the classifier air vortex are controlled carefully so that each individual particle is open to the same action. And the machine is designed so that the heavy flow of solids through the machine does not interfere with free reaction of each particle to the forces.

A particle rotating with the air vortex will be dominated either by centrifugal force or drag force from the air moving radially inward. If larger than the established cutsize, the particle will move outward under centrifugal force; if smaller, it will move inward with the air stream.

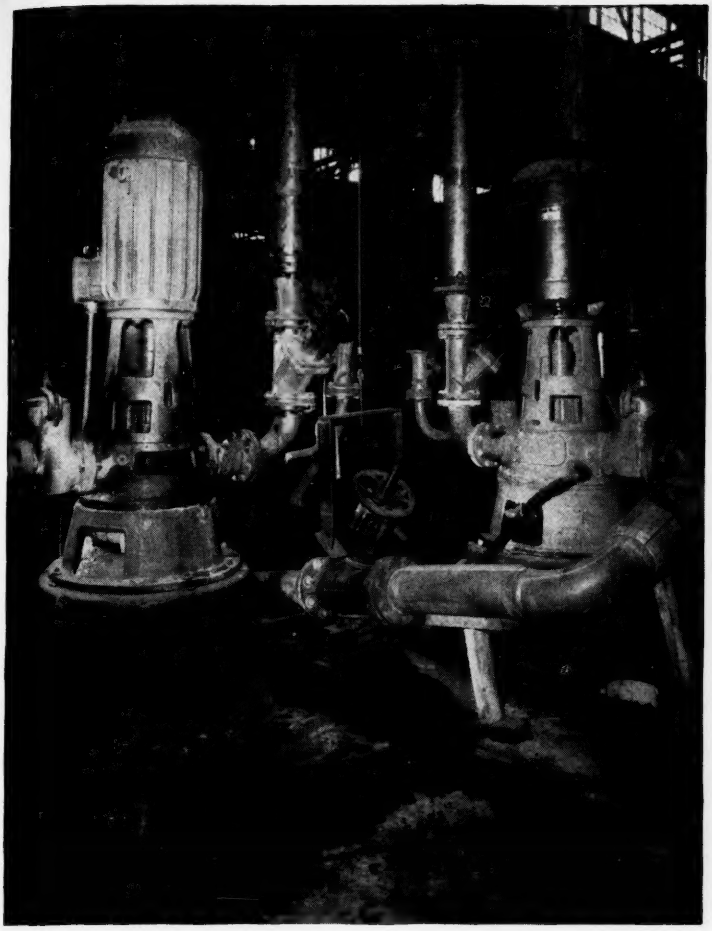
Particles are inside the machine only a fraction of a second or just long enough for the separating forces to do their job. Before the entering powder is fed into the classification zone, it is accelerated to the same velocity as air in the vortex.

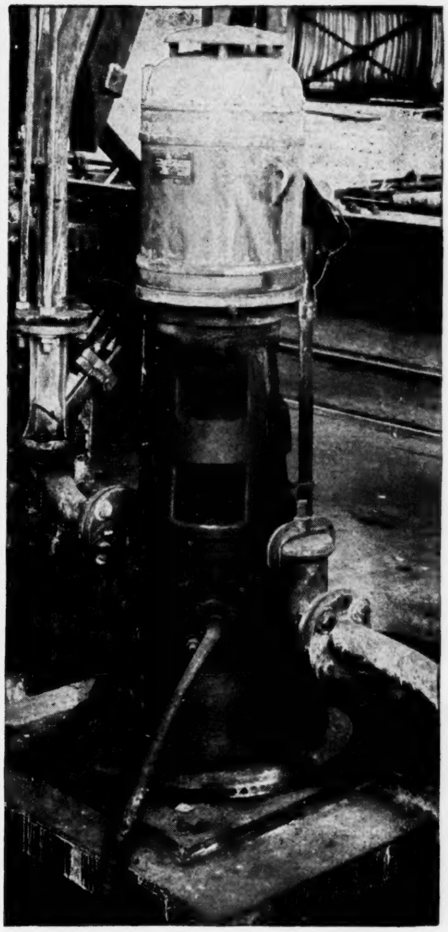
Top and bottom plates of the classification zone rotate at the same velocity as the air, largely eliminating frictional effects. These specially shaped plates converge to increase velocity of the air as it moves inward toward the center of the vortex. Net result is a constant relationship between centrifugal and drag forces.

Design of the machine is tailored carefully to eliminate flow of excess air and, thereby, hold down size of air-handling equipment.

▶**To Fork in Road**—Feed enters through funnel at top of machine and falls onto impeller-like rotating distributor. Blades on the distributor accelerate the powder and deflect it outward through tubes in the top plate of the rotor.

Powder discharges, with con-





"Almost No Maintenance" Since 1947

Back in 1947, Canadian Copper Refiners Limited installed a Type G LaBour packingless pump to handle electrolyte at their Montreal East refinery. Performance has been completely satisfactory, says the plant management, with almost no maintenance. In 1955 this company installed three more Type G LaBours and reports "similar satisfactory performance" from the newer units.

This experience is typical of many. Chemical men who have had LaBour pumps actually working for some time are best informed, and they usually insist on LaBours when it comes to expansion or replacement of older equipment. These men know that true economy in pumping comes only from dependable, day-in day-out service—the kind of service for which LaBour Pumps are recognized all over the world.

If you've had no direct experience yourself with LaBour pumps, we urge you to consult those who have. We'll be glad to help you.

ORIGINAL MANUFACTURERS OF THE SELF-PRIMING CENTRIFUGAL PUMP

LaBOUR

THE LaBOUR COMPANY, INC. • Elkhart, Indiana, U.S.A.

Equipment Developments This Month

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siderable deagglomerating action, through nozzles in the tube ends into the center of the classification zone.

Air flow, induced by a blower downstream from the classifier, enters the classification zone through the top and bottom vanes shown on cutaway view. Particles coarser than the cutpoint are carried outward where they contact collector rings. These rings guide the particles around the classifier until they reach the outlet port and are discharged to a built-in airlock valve.

Particles finer than the cutpoint move inward and discharge into the fines discharge scroll, then to a collector which removes the solids from the air stream.

▶ **Operating Hints** — Classifier operates continuously and, once started, with minimum operator attention. Instrumentation is needed only to measure air flow rate and the differential pressure across the system.

Machine can be adjusted to a different operating cutpoint merely by changing the two air-inlet vane rings and a drive sheave, which takes less than an hour.

Design of the classifier minimizes abrasive wear. In the few places such as the powder feed tubes and nozzles where the powder moves with high velocity across surfaces, readily replaceable inserts are provided. And complete sealing keeps particles from entering the spindle assembly.—**Sharples Corp., 2300 Westmoreland St., Philadelphia 40, Pa.** **184A**

Process Screen

Offers accessibility for rapid cleaning of all parts.

Designers of the new Gyroshaker screen aimed to provide some clear-cut advantages for process application. It is reported ideal for use where all points of the screen must be easy to reach for cleaning. It will fit where process layout requires a minimum over-all height and where a highly efficient single screen is preferred to a multi-sieve stack.

Case and drive of the Gyro-Shaker are mounted flexibly on a base consisting of a floor plate, a vertical tubular steel column and a suspension frame. Drive force is developed by an eccentric lead balance weight attached to a vertical shaft which is mounted on two heavy duty, self-aligning roller bearings. As the shaft rotates, the eccentric weight imparts a flat horizontal gyratory oval motion at a frequency of 610 to 630 rpm.

Unit is constructed of carbon steel with top cover and screen frame of aluminum. All parts contacting the product can be constructed of stainless steel. If needed, the unit can be made tight to operate under inert gas pressure.—**Sprout, Waldron & Co., Muncy, Pa.** **186A**

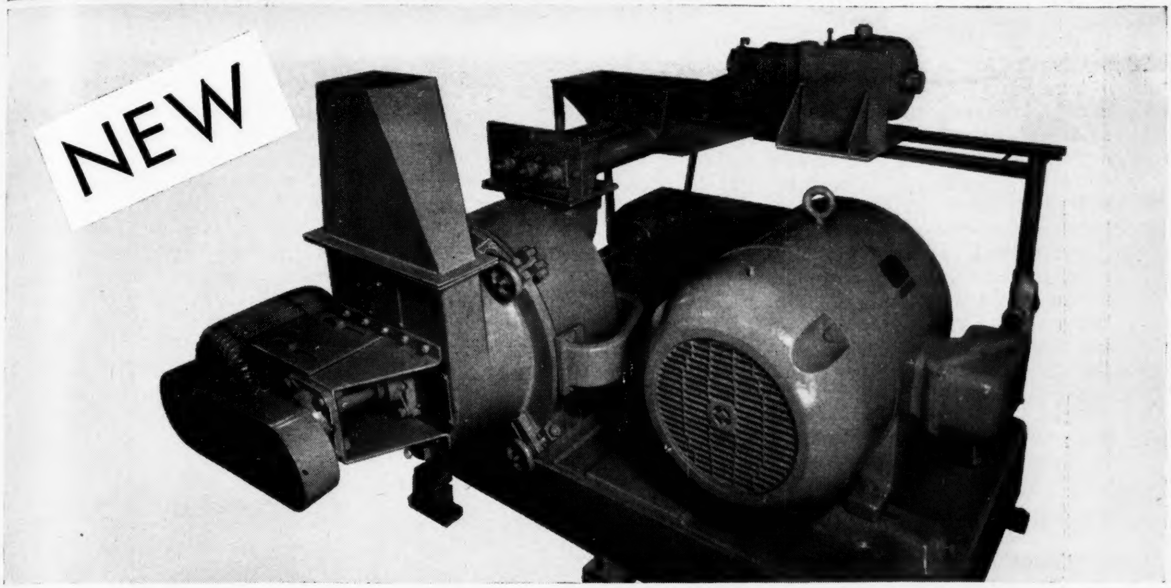
Ribbon Mixer

Triple-action agitation and drop-bottom discharge.

As little as 5 to 10 grams can be distributed by the new Triple-Action mixer throughout a ton of dry solids in less than 15 min. blending. Uniformity of distribution is within 0.5% throughout the batch.

The inner ribbon on the agitator assembly is wider than usual to agitate and blend more thoroughly toward the core of the solids mass in the tub. Along the agitator shaft is a screw or scroll which breaks the core of the mix to blend it faster and more efficiently

NEW PRODUCT NEWS



FOR PRECISION GRINDING AND CLASSIFYING IN ONE OPERATION

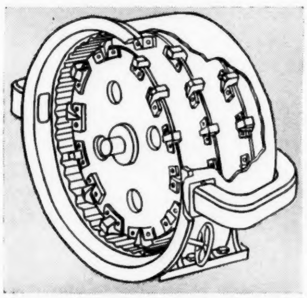
The PULVOCRON . . .
An Air Attrition Impact Pulverizer and Classifier with Controlled Radial Inward Air Classification.

Now in one compact unit you can have a pulverizer and a classifier plus an automatic feeder, with separate controls over each. This assures positive particle size control and high capacity over a wide range of products. The Pulvocron will produce particle sizes from a range of 99% less than 5 microns or as coarse as 50 mesh, depending on the material and desired results.

The grinding chamber contains three adjustable plates with twelve staggered beaters on each. It also features added versatility through interchangeable liners of corrugated, perforated or smooth finish, plus variable rotor stator clearances.

The Classifier unit is on a hinged section with quick-open locks for simplicity of operating adjustment or cleaning.

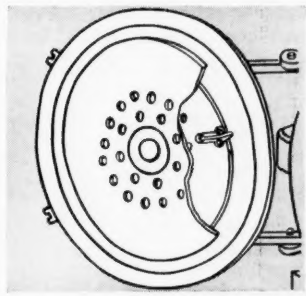
Material is both ground and classified through high centrifugal pressures set up by the beater and classifier plates. The Pulvocron is designed with oversize returns for automatic feed back of any oversize for further grinding.



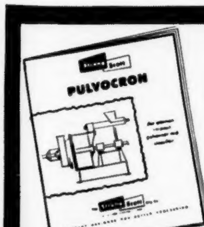
Grinding chamber with adjustable plates, removable liners and oversize returns.

CONSULT STRONG-SCOTT

Strong-Scott offers you a modern up-to-date laboratory containing specialized testing equipment. This is backed by an expert engineering staff to furnish layout and design service at no additional cost to you.



Classifier Unit with separate motor. Swings open as a hinged section with quick open locks.



WRITE FOR FREE COLOR BULLETIN

The Strong Scott Mfg. Co.

DEPT. CE-NPB6-645

Equipment Designed for Better Processing

451 TAFT STREET N.E., MINNEAPOLIS 13, MINNESOTA

throughout the entire mass of solids.

Mixer has outboard bearings and nylon seals between the agitator shaft and the stationary ends of the tub. Thus, cleaning is easier and the possibility of cross contamination between batches is eliminated.

Drop construction of the tub permits immediate discharge of mixed batch. Interior of the tub and the agitator mechanism are more easily accessible for cleaning and maintenance. **—Strong-Scott Mfg. Co., 451 Taft St., N. E., Minneapolis 13, Minn.** **186B**

Filter Medium

Made of wire mesh, handles like metal plate.

Similar in nature to metal plate, Rigimesh rigidized wire-mesh filter medium can be fabricated by cutting, rolling, corrugating and welding without loss of the original uniformity of mesh openings. Thus, a filter element of Rigimesh can be rated reliably for particle size retention.

Filter elements of Rigimesh are claimed stronger, lighter, resistant to corrosion and temperature, and reuseable. Filters with these elements now operate over a wide range of services. Limits cited by the manufacturer are −65 to 900 F., vacuum to 10,000 psi., retention of particles from 2 to 2,000 microns.

Rigimesh is made by furnace welding the wires of the mesh at all contact points. Rigimesh media also are used with two or more layers bonded together to form a homogeneous laminate. One such type employs a thin, fine facing bonded to a coarse backing mesh.**—Pall Filtration Companies, 30 Sea Cliff Ave., Glen Cove, N. Y.** **188A**

Equipment Cost Indexes

Industry	June 1956	Sept. 1956
Avg. of all	204.2	211.3
Process Industries		
Cement mfg.	194.8	201.6
Chemical	204.3	211.5
Clay products	189.2	195.8
Glass mfg.	193.0	199.8
Paint mfg.	196.6	203.5
Paper mfg.	196.9	203.8
Petroleum ind.	200.7	207.7
Rubber ind.	203.2	210.3
Process ind. avg.	201.4	209.0
Related Industries		
Elec. power equip.	206.2	213.4
Mining, milling	205.6	212.8
Refrigerating	229.0	237.3
Steam power	192.5	199.2

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago, for 47 different industries. See *Chem. Eng.*, Nov. 1947, pp. 124-6 for method of obtaining index numbers; March 1956, pp. 194-5 for annual averages since 1913.

Pressure Filter

Discharges filter cake by centrifugal force.

By using centrifugal force, the Funda filter discharges cake at the end of each cycle without need for opening the tank. Because of this discharge mechanism, filter surfaces are designed to assure clear filtrate.

Filter consists of a pressure vessel containing a number of circular filter elements mounted on a hollow shaft. Stainless-steel screens or cloth-covered screens cover the top surface of the elements.

Precoat and cake form on the top surfaces so that they cannot fall off. Liquid passes from the pressure vessel through the filter elements into the shaft.

After filtration is completed and the vessel has been emptied, the vertical hollow shaft rotates to throw off the cake by centrifugal force. At the same time a stream of backwash water is directed through the hollow shaft and out through the filtering surface. Entire cleaning process takes about 1 min.**—A. G. fur Chemie-Apparatebau, Mannedorf-Zurich, Switzerland.** **188B**

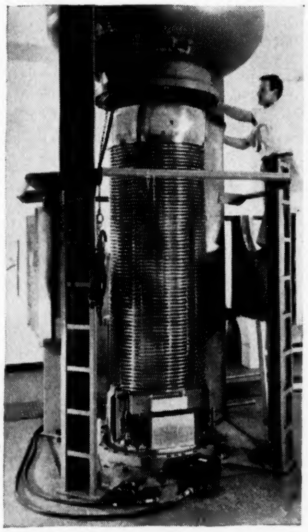
Flotation Machine

For high-rate, roughing operations on ore or waste.

A high degree of aeration and agitation at lower horsepower is claimed for the new Type M flotation machine. It is recommended for roughing or scavenging on any type of flotation operation.

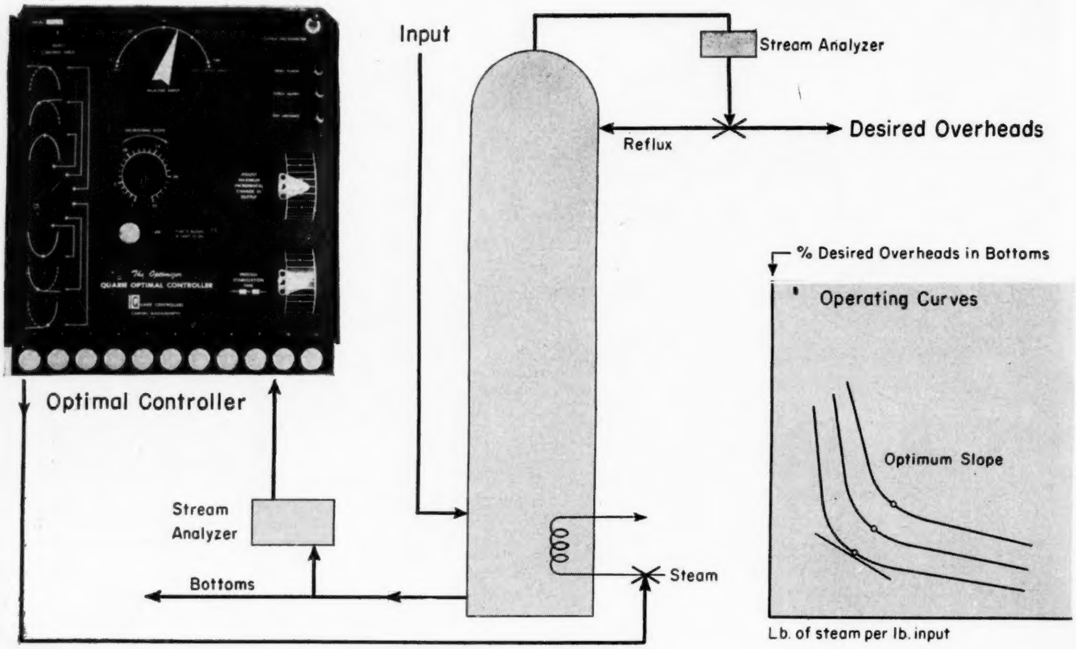
Construction of the Type M machine is simple with an aerating impeller and agitating propeller suspended from a drive mechanism in a large tank. Combination of propeller and impeller creates three distinct zones: agitation and aeration, aeration, separation.

In addition to providing entrained air, the Type M unit produces dissolved air to make aeration more effective and boost efficiency.**—Denver Equipment Co., 1400 17th St., Denver 17, Colo.** **188C**



Powerful Atomic Probe

This new 3-million-v. Van de Graaff accelerator now is operating at Shell Development Co.'s Emeryville, Calif. laboratories. With it, a specially trained group of scientists will probe to learn more about what goes on between and inside molecules during certain processes. Short-lived, active molecular fragments that are essential in chemical reactions can be produced at sub-zero temperatures and kept in crystalline lattices for study at leisure. With radiations 50 times more powerful than the largest cobalt-60 source in industry, the Van de Graaff machine provides a new type of energy that may lead to new methods for manufacturing chemicals. **188D**



Controller Holds Process at Optimum Point

Even though process conditions change, a new controller automatically holds process at the optimum operating point. Concept relies on slope control.

Both process and cost can be controlled simultaneously by the new Optimal Controller, an instrument with a built-in pocketbook nerve.

▶ **Balances Process Costwise**—Based on a new concept, the Optimal Controller holds a system or process at a particular slope on its operating curve rather than at a fixed temperature or pressure.

When uncontrolled variables in the process cause the operating curve to shift, the optimal controller holds the system in balance at the same optimum slope, but on the new operating curve. Thus, output of the process remains at an optimum from the cost standpoint.

Of course, the optimum slope must be determined by calculation and "set in" to the instrument. Then, the instrument takes over and controls to that slope even as the operating curve shifts.

Set points used with conventional control techniques are based on engineering data which has been well evaluated with allowances included where needed. However, day to day variations in the onstream conditions cannot possibly be evaluated and included in the allowances.

The Optimal Controller follows these conditions as they change and continuously seeks and holds the best compromise in onstream conditions. The true worth of the controller is measured in throughput gained as the device holds to optimum conditions.

▶ **Rate of Change**—Slope used for optimal control is rate-of-change of an uncontrolled variable, or ratio, with respect to a controlled variable. It is not a rate of change with respect to time.

An example of this is shown above in the flow chart and curves for the separation of isopentane from normal pentane. Also, it shows you the relationship between slope of the curve and the cost factor.

Overheads are held at constant purity by controlling the reflux rate. Bottoms are analyzed for isopentane and the result used as input to the Optimal Controller. Output of the controller is steam flow to the tower.

Note on the curves that when large amounts of steam are used, very little isopentane will be lost. Too little use of steam will allow considerable loss of isopentane.

Thus, there is some slope on this curve where the value of lost isopentane balances the cost of steam needed to regain it. This will be the optimal slope. At this point, the process is at the optimal cost balance.

A family of curves exists for the process because of varia-

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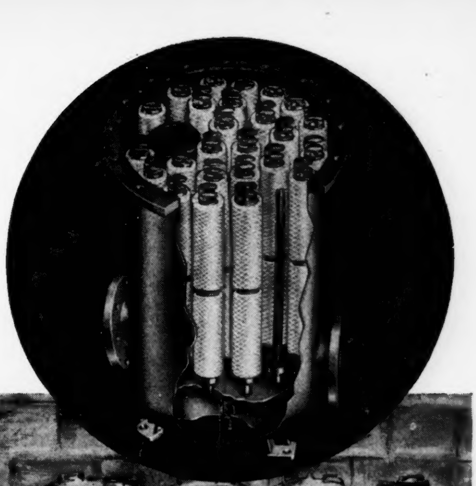
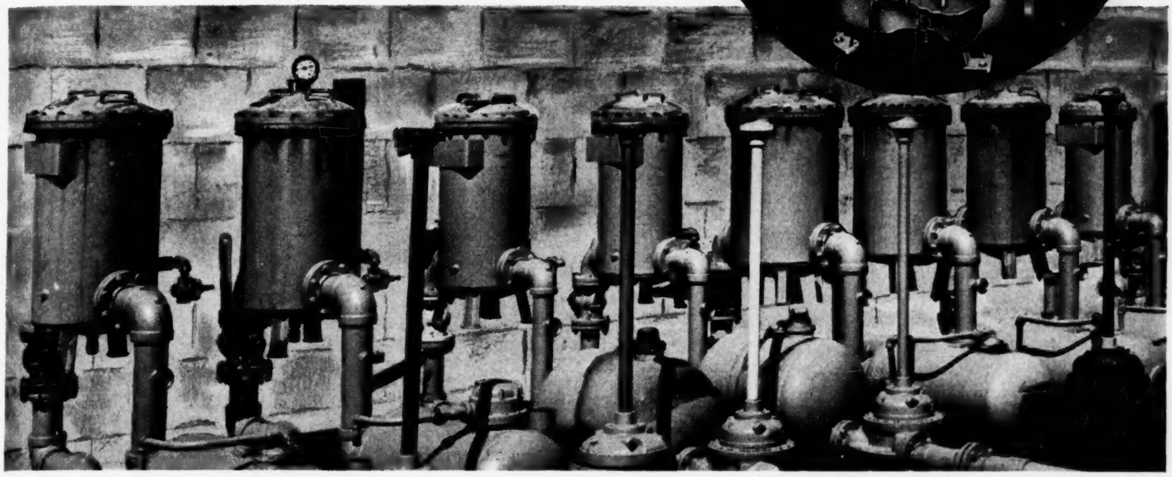
WHEN YOU WANT...

Continuous Micronic Clarity
in flow rates up to 2000 GPM
or pressures up to 5000 PSI



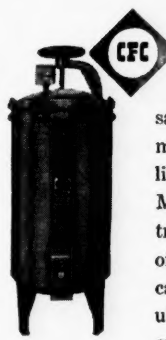


These Multi-Tube Fulflo Filters employ Honeycomb Filter Tubes to provide micronic clarity of liquid chemical solutions at continuous high flow rate.

Improve Product Quality — Increase Production — Decrease Costs

You get almost any degree of *continuous micronic clarity* with Fulflo Filters: for liquid chemicals and petro-chemicals; pharmaceuticals; water; CO_2, compressed air, and other gases; liquid fuels; oils; various commercial fluids. Fulflo Filters handle flow rates up to 2000 gpm or pressures as high as 5000 psi, with minimum pressure drop. Fulflo will *not* remove additives from oils.

There's a Fulflo Filter to meet your exact needs for liquid or gas filtration. *Genuine* Honeycomb Filter Tubes are available in a wide variety of positively controlled densities. You have a broad selection of materials — filter elements in cotton, nylon, orlon, dacron, dynel, acetate, or glass fibres; containers of iron, steel, stainless steel, rubber-lined steel or nickel plated brass. Special containers, elements and sizes can be engineered to your *individual* requirements. Fulflo assures you of *high* clarity at *low* cost.



CFC Oil Filters (including former Honan-Crane models) effect substantial savings by prolonging equipment life and by extending the life of all types of oils. The CFC Multi-Cartridge Filter (illustrated at left) gives you a choice of six types of interchangeable cartridges for filtering both soluble and insoluble impurities in cutting, quenching and rolling-mill oils; turbine and vacuum pump oils; fuel and lube oils.

Commercial Filters Engineers are ready to help you with any problem of fine filtration. Write for technical literature to Department CE.

Micro-Fine Filtration for Low Cost Clarity

COMMERCIAL FILTERS CORPORATION

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Plants in Melrose, Massachusetts and Lebanon, Indiana

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PURIVAC INSULATING OIL CONDITIONERS • DRI-PURE WATER-OIL SEPARATORS • PRE-COAT FILTERS • MAGNETIC SEPARATORS
AUTOMATIC TUBULAR CONVEYORS • COOLANT CLARIFIERS

tions in composition of input, tower pressure and ambient temperature, to name a few. Most processes will be found to have such a family of operating curves.

With a conventional controller which holds to a set point, the existence of these different curves is ignored because there is no way to compensate for the variations. The Optimal Controller, however, holds to the optimal slope on whichever curve characterizes the operation at a given moment.

▶ **How Controller Works** — The Optimal Controller is a combination of a conventional controller and a simple analog device which recognizes only three conditions:

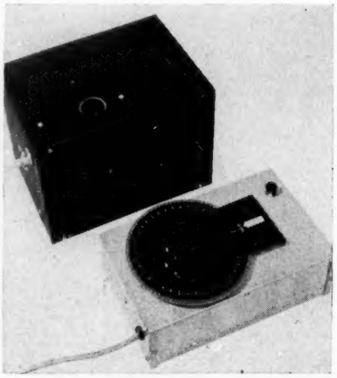
- The optimal point is in the direction toward which control is operating. Make another change in the same direction.
- The optimal point is in the opposite direction. Reverse the control direction and change the system input toward the optimal point.
- The system is at the optimal point. Stop control action but keep checking that the system itself does not change.

Basically, this controller makes a step-change in the process input. It predicts what the new value of the process output should be, based on the change and the desired slope. After waiting for the process to stabilize, it compares the actual process output to the predicted value and acts on one of the three conditions listed above.

As the required control slope is approached, the discrete changes of process input decrease gradually to zero. These discrete changes also have an adjustable maximum value so that steepness of the characteristic curve is taken into account to avoid process upset.

Once setup properly, the controller will hold the process at the optimal point and will not hunt. System changes which grossly upset conventional control methods have very little effect on optimal control.

▶ **Good Reliability** — Since the controller inherently changes the control parameters of a process, it must be as reliable and fail-safe as possible. The Optimal Controller is completely self-checking on each cycle. If a component fails, instrument disconnects itself from the process leaving it at the last set point and signals an alarm.—**Quarie Controllers, P. O. Box 95, Canton, Mass.** **190A**



Remote Positioner

Costs less than existing automatic positioners.

Automatic positioning control for a wide variety of industrial applications is provided by a new, low-cost device. Without using vacuum tubes or photocells, the Model AS positioner is accurate within 0.5% with a repeatability of 0.25%. It depends on bridge circuitry.

Among the uses for this automatic positioning control are positioning of conveyors, valves and dampers, remote instrumentation in conjunction with indicating instruments, controlling operation of automatic selection equipment.—**Wallson Associates, Ltd., 245 Wallace, Orange, N. J.** **192A**

Handwheel Operator

Mounts integrally on standard valve actuator.

In the event of air failure, the Cono-Clutch hand operator makes possible immediate manual control of the cylinder Conomotor power actuator. Device mounts integrally on standard Conomotor line which is used for throttling valves, on motor-driven speed changers, on proportioning pumps, and on flow regulators.

Cono-Clutch is said to be the only operator of its type which can be thrown instantly in and out of gear at any position of stem travel. Clutch is operated by pulling or pushing knob on the face of the unit. When the clutch is disengaged, there is absolutely no interference with full and free stem travel.—**Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.** **192B**

Gas Chromatograph

For analyzing one to five process streams.

Designed for continuous cyclic analysis of gaseous or liquid process streams, the Chromacon Series 9485 gas chromatograph is available in two models to handle either one or up to five streams. It can be used on a wide variety of process analysis jobs in natural gasoline plants, refineries and petrochemical plants, and chemical plants.

Sample is charged automatically to the instrument. A timer controls frequency of analysis from 1 to 12 per hr. Operating temperature range is 25 to 150 C. Instrument is furnished complete with recorder, detector cell and automatic charging device.—**Podbielniak Inc., 341 East Ohio St., Chicago 11, Ill.** **192C**

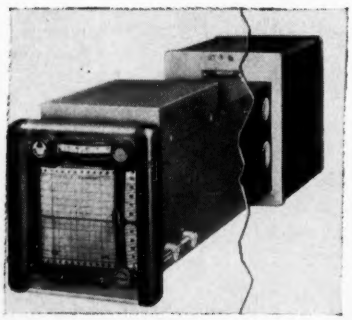
Instrument Cabinets

Building block enclosures fit many industrial needs.

An infinite variety of housings for instrumentation and allied equipment can be fabricated by selecting components from 75 mass-produced metal-cabinet enclosures and 125 different sub-parts. With this standard line, industry can satisfy 75% of its enclosure needs for instrumentation and automation equipment.

Components are built of cold rolled, heavy gage steel finished in two-tone gray baked enamel with a Bonderite base. Skeleton frames are airplane type.

Forty different types of panels and four different drawer sizes make up the component parts which can be fastened to the frames.—**Elgin Metalformers Corp., 630 Congdon Ave., Elgin, Ill.** **192D**



Unitized Controls

All-electronic line in single universal case.

With the new Unitized Autronic all-electronic control system, you can contain any combination of units within a universal mounting case which requires a single standard panel cutout of only 5 x 5 in.

Controller, recorder or indicator, and manual control are constructed to plug in. Wiring has been eliminated between individual instruments. For calibration, test or maintenance, instruments can be pulled out of the panel easily without using jumpers or upsetting system balance.

Incorporated in the new controls are all the latest advances such as printed circuits, miniature tubes and ruggedized components.—**The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.** **194A**

Computing Relay

Performs any of six different arithmetic functions.

Model 56-1 universal pneumatic computing relay can be adjusted to add, subtract, multiply and divide. Measurements are received by the relay as 3-15 psi. pneumatic signals; computer output to a recorder or controller is 3-15 psi. signal.

New relay operates by force balance with four bellows to position a floating disk about a fulcrum. Disk acts as the flapper of a conventional flapper-nozzle detector.

Forces exerted by pressures in the bellows establish the disk position relative to the nozzle. Resulting pressure change in the feedback bellows maintains the balance position of the disk.

External connections to all four bellows are provided by a manifold so that measurement signals can be received and computed according to the equation desired.—**Foxboro Co., Foxboro, Mass.** **194B**

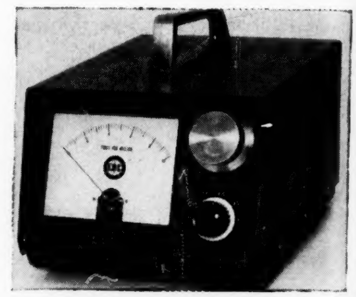
Fabricated Venturi

Light weight, low-cost unit delivered promptly.

Offering a decided price advantage, the new Type PVF fabricated Venturi tube is available on relatively fast delivery compared with heavier cast-iron tubes.

Tubes conform to standard Venturi dimensions. The entire inner formed section is constructed of stainless steel. Either carbon steel or stainless-clad steel pipe forms the surrounding and supporting section.

Main pressure belt is a formed channel which may be eliminated entirely should a single-tap design be required. Throat pressure belt ordinarily is formed by the space between the outside pipe and the configuration of the stainless insert section. For single-tap construction, a pipe tap extending from the outside of the pipe to the throat section of the insert tube effectively seals off the throat pressure chamber. — **Burgess-Manning Co., Penn Instruments Div., 4110 Haverford Ave., Philadelphia 4, Pa.** **194C**



Moisture Monitor

Measures minute amounts of moisture in gases.

As little as 1 ppm. of water in gaseous mixtures can be measured accurately by the new portable Type 26-301 moisture monitor. Unit reads precisely over the full-scale range of 0 to 1,000 ppm. by means of a 5-step attenuator. Output can be telemetered to recorder.

Sample flows through the instrument at a precisely controlled rate at temperatures up to 100 C. and pressures up to 100 psig. All water present in the stream is absorbed and electrolyzed by a cell within the instrument.

A d.c. voltage is applied to the cell and the electrolysis current measured with a multi-range meter. Since the electrolysis current is related directly to the water mass rate-of-flow through the instrument, it is an indication of water content in the sample.—**Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif.** **194D**

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We're on Stream!

New Phthalic Anhydride Plant Doubles Pittsburgh Coke's Output of Essential Material

PITTSBURGH COKE is now *producing* and *shipping* from its new multi-million dollar phthalic anhydride plant!

Under construction since last year, this efficient new production unit is engineered to keep pace with the chemical industry's steadily growing needs for basic supplies of high purity phthalic in both flake and molten form.

Now, more than ever before, you can count on Pittsburgh for the prompt deliveries and uniform phthalic quality that eliminate many of your production troubles.

Call in a Pittsburgh man today! He'll show you how to solve your P.A. supply problems *before* they happen—by going with Pittsburgh in '57!

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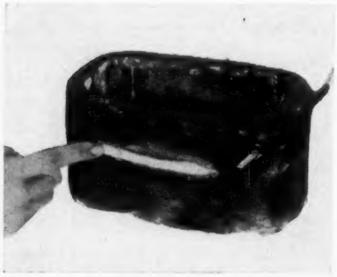


Motor Coil Insulation

Resists chemicals, oil, moisture and dirt particles.

An integrated field coil with a newly developed insulating system now is available for motors or generators that must resist atmospheric contaminants and destructive mechanical forces.

Primary insulation in the coil is glass with fibers tailored and oriented for maximum strength. Solventless, inorganic, heat-stable resins augment the glass fibers. Fiber and resin fuse together into one integral part.

In many applications, integrated field coils complement Silco-Flex all-silicone-rubber insulated stator coils. Together, they are said to solve the toughest operating conditions for motors and generators in Class A or B service. Included in this category are air-borne carbon black and metallic dust particles.—**Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.** **196A**

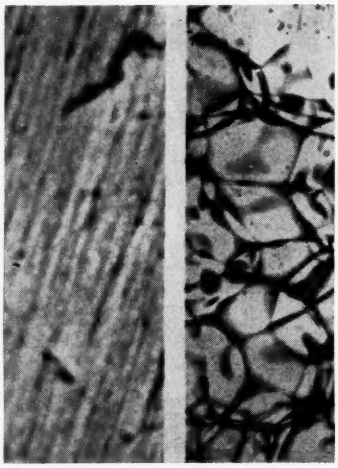
Atomic Flashlight

Provides light for years without any battery.

Utilizing an essentially nonhazardous radioisotope, a new flashlight is available with a variety of light outputs and colors. With the light from just one of these devices, you can read a map in total darkness.

Illumination from the light diminishes at a very slow rate since the half-life of the isotope is 12 yr. By varying composition of the reactive mixture, green, yellow or blue color is produced.

Variable climate, moisture, temperature and other external factors do not affect continuous emission of light from the device. Uses are foreseen in illumination of dials and critical controls, as location markers at building exits and as emergency lights.—**New England Nuclear Corp., 575 Albany St., Boston 18, Mass.** **196B**



X-Ray Microscope

Opens new vistas in study of metals, coatings and corrosion.

You see here an aluminum-tin alloy as revealed by an ordinary light microscope and, by comparison, the new G.E. X-ray microscope. The complete grain outline seen through the X-ray microscope shows you where dark areas of tin are located.

With the X-ray microscope, you may view objects either directly or record the image on film. While this microscope is not as powerful as the electron microscope, it can be used without mounting the specimen in a vacuum or other special preparation techniques.

Compared to the optical microscope, the X-ray microscope offers an advantage in depth of focus which permits three-dimensional examination of the specimen. No special sectioning of sample is needed.

Inherently, the X-ray microscope will penetrate to the interior of an object and reveal structures not visible otherwise.—**General Electric Co., X-Ray Dept., Milwaukee 1, Wis.** **196C**

Nuclear Reactor

First to be mass produced is safe and low cost.

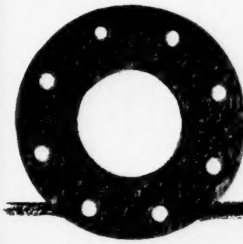
Startup of the AGN 201 research and training reactor on October 25th culminated development of a new reactor concept. This unit is designed for mass production to sell at low cost, a milestone in the economic application of atomic energy. A price tag well under $100,000 is reported.

Reactor went critical with 656 grams of U_{235} in the form of 20% enriched uranium oxide.

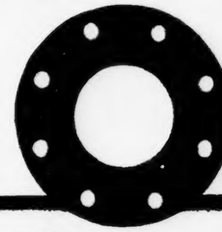
Design features make the AGN 201 the safest reactor known to be operating at this time, according to the manufacturer. Among the many foolproof safety features is a thermal safety fuse built into the core.—**Aerojet-General Nucleonics, San Ramon, Calif.** **196D**

High-capacity V-belt offers up to 40% more strength than standard belts. Drive costs can be lowered since you can handle given load with fewer belts and narrower sheave.—**Thermoid Co., 200 Whitehead Rd., Trenton, N. J.** **196E**

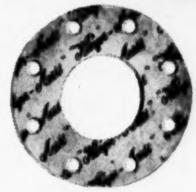
Static switching control system performs same control functions as contacting relays. System aids automation of various low-power switching operations, reduces or eliminates failure from wear, fatigue or harsh environment.—**General Electric Co., Schenectady 5, N. Y.** **196F**



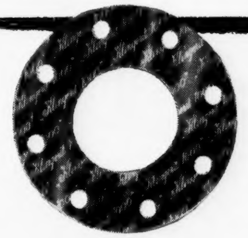
"KLINGERIT" The universal sheet packing for super-heated and saturated steam, acids, alkalis, and other chemicals, oils, spirits, solvents and hydrocarbons, hydraulic pressures, compressed air and other gases.



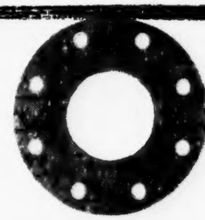
"KLINGER-OILIT" Primarily for use in the oil industry and suitable for trichlorethylene, carbon tetrachloride, naphtha and many other chemicals up to 900°F. Also for use with many refrigerants. It is made mainly from inorganic materials and is suitable for the highest temperatures and pressures.



"KLINGER-ACIDIT" For hot nitric, hydrochloric, sulphuric and all other organic and inorganic acids. It is not damaged by oils, gasoline and other solvents and has been tested to 500°C and 1,000 p.s.i.



"KLINGERIT-1000" Has as its base a tough close-mesh wire gauze in specially prepared asbestos compound, forming an extremely strong homogeneous jointing material. It is better able to resist blowing out than any other jointing, and is recommended for extremely high temperatures.



"RK" For most conditions of pressure and temperature encountered in general engineering practice. It is suitable for super-heated and saturated steam, water, compressed air and other gases and most chemicals.

Write for the Klinger Master Catalog which describes the complete range of Klinger products.

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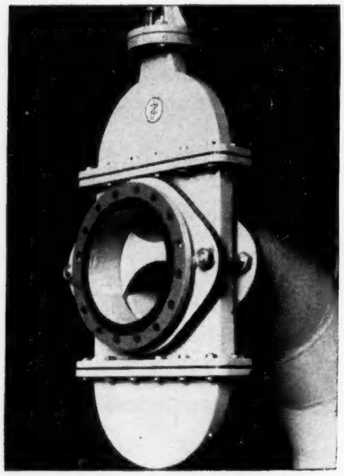

Slide Valve

Handles low-pressure contaminated gases.

Low pressure gases with entrained contaminants can be regulated with a new lightweight slide valve. Design permits easy cleaning of valve to remove deposited material.

Valve has a disk which slides between flange stubs arranged flexibly in the housing. When the disk is open, the flow passage is completely smooth. Only when the slide plate is moved can dirt or dust penetrate into the interior housing. But the slide hood and lower part of the housing can be removed at any time to permit easy cleaning.—**Zimmermann & Jansen, G. M. B. H., Dueren-Rheinland, Germany.** **198A**

Tube Fitting

Makes foolproof, butt-tight joint for pressure range.

New Hi-Seal flareless tube fitting withstands high pressures, hydraulic surge, vibration and other severe operating conditions.

Fitting forms a butt joint so that tubing need not be sprung when making assemblies. This is particularly advantageous when working with large-sized, heavy wall or hard-temper steel tubing which are all difficult or impossible to spring.

Hi-Seal fitting consists of a body, nut and alloy-steel sleeve. Shoulder on sleeve prevents incorrect assembly.

Three serrated edges on the sleeve bite into the tube surface radially to a controlled depth, making a triple seal. It will not move longitudinally, scrape or shave tubing. There is no need for flaring or threading to disassemble and inspect. —**Imperial Brass Mfg. Co., 1200 Harrison St., Chicago 7, Ill.** **198B**

Expansion Joints

Are more flexible to give uniform movement.

First basic design change in Badger's expansion joints within recent years, incorporates a different shape in the corrugations which form the flexing member.

The new shape makes the height of each corrugation more effective by contributing to flexibility and more uniform movement per corrugation. Under operating pressures and temperatures, the new corrugation assumes a completely curved shape and actually exhibits a breathing movement as pressure fluctuates.

In ratings for 150 psi. and higher, Service-Rated joints have reinforcing rings claimed to offer the most significant improvement in expansion-joint engineering to date. These tubular rings contact the corrugations only in the valleys. In this fashion, the rings maintain the hoop dimension of each corrugation allowing it to assume a completely curved shape when under line pressure.

Service-Rated joints are available in any weldable alloy for pipes from 3 to 72-in. dia.—**Badger Mfg. Co., 230 Bent St., Cambridge, Mass.** **198C**

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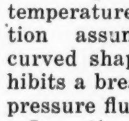

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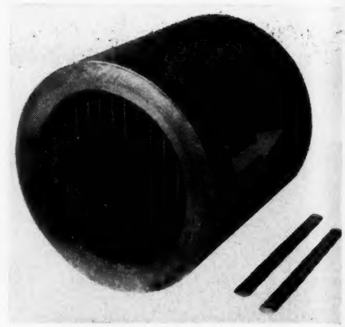


Entrainment Separator

Impingement type of resistant graphite.

Compact and ready to insert into a pipe line, the Type MV scrubber is an impingement-type entrainment separator made of Karbate-brand impervious graphite.

Separator has staggered rows of streamlined graphite rods as impingement surfaces for gas-entrained liquid particles. At 1-atm. pressure, unit is designed for gas velocity of approximately 30 ft./sec. Pressure drop will be less than 1-in. of water column.

Over an operating range from 0.1 to twice design range, separator will remove 99.8% of 11 micron water particles from air and 93% of 7.8 micron particles.

Separator is available from stock in 6, 8, 12 and 16 in. dia. cylinders, 22-in. long. Each cylinder can be installed between the faces of 150-lb. ASA flanges with no enlargement of the pipe.—**National Carbon Co., 30 East 42nd St., New York 17, N. Y.** **198D**

Rotary Joint

Compact design suitable for wide range of pressures.

New type C rotary joint simplifies selection specifications for use on steam, air, water, oil, gas or alternating hot and cold service. Joint is almost universally suitable for steam pressures from 0 to 200 psi. and hydraulic pressures to 400 psi.; for temperatures to 450 F. or 500 F. special duty and for any rotating speed.

Type C can be installed for either single flow or two-way syphon flow. It has low starting and running torque, even at high pressure. Bearings and seal are self-lubricating and the seal is self-adjusting for wear.

These joints are expected to find wide use where steam, water or other fluid is piped into rotating drums, dryers or rolls.—**Barco Mfg. Co., Dept J 10, 500 Hough St., Barrington, Ill.** 198E

Airfoil Fan

Uses aerodynamic design for better performance.

In the Axial Airfoil fan, the blades closely resemble the appearance of an aircraft wing. Result is higher pressure characteristics with less operating noise.

Blade has a thick airfoil section and large angle at the hub which decrease to a thin section and small angle at the tip. The hub-tip ratios are such that air is delivered at a more uniform velocity across the entire fan blade and back flow is eliminated around the hub.

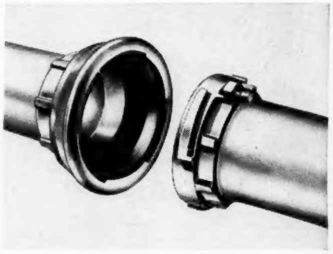
Fans are available with two, four, six and eight blades to satisfy required pressure-volume characteristics. Fan diameters are reported to run from 12 to 72 in. with air-moving capacity certified to be 1,200 to 100,000 cfm.—**Chicago Blower Corp., 9863 Pacific Ave., Franklin Pk., Ill.** 200A

Light-Gage Tubing

Welded from aluminum at any degree of hardness.

The lightest gage tubing now being commercially welded is a new aluminum tubing. It is claimed to be stronger than extruded or butt tubing and is designed for applications requiring greater material strength and weight reduction.

Any aluminum alloy at any hardness can be welded by this new process into tubing from under 0.050 down to 0.025. Manufacturer claims this new tubing is low in cost, has easy workability and resists corrosion from most industrial atmospheres, gases and liquids. —**Jo-El Co., 14209 Leroy Ave., Cleveland, Ohio.** 200B



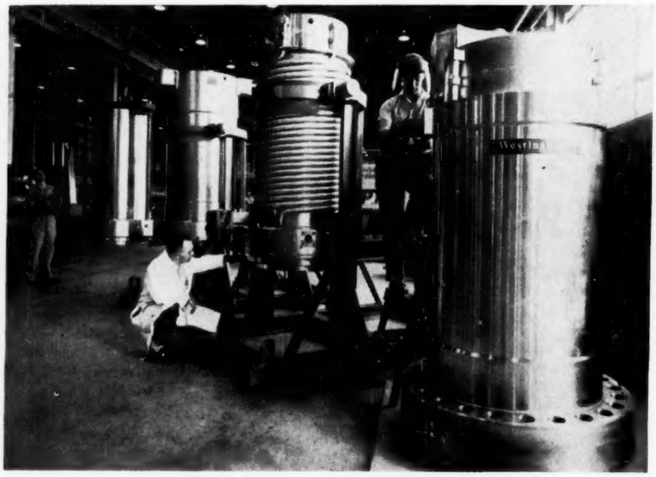
Pipeline Coupler

Used with portable aluminum lines up to 1,000 psi.

A coupler available in both OD and IPS pipe sizes for working pressures up to 1,000 psi. now is being used with portable aluminum pipelines. New lightweight pipelines can be moved from six to 10 times faster than older types of portable pipelines. And with the FMC fast-move coupler, such lines are easy to dismantle and clean at any time.

According to the manufacturer, the FMC coupler is without doubt the fastest-acting one designed and accepted for this type of use. Heavy breach-acting jaws secure the coupler with a quarter turn. A lock screw spins up in an instant to lock the coupler against untwisting through excessive line torque.

No metal part of the coupler is exposed to the material in the line. A special aromatic-resistant Buna-N gasket that seals with pressure is placed so that there is almost no disturbance of flow.—**John Bean Div., Food Machinery & Chemical Corp., San Jose, Calif.** 200D



Pumps for First U. S. Atomic Electric Plant

Canning season is almost completed as Westinghouse enters final stages in construction of four 1,600-hp., 2,300-v. canned motor pumps for the nation's first full-scale atomic electric generating station at Shippingport, Pa. Each pump circulates, in the primary loop, 18,300 gpm. of radioactive water at approximately 2,000 psi. up to 600 F. That's why each pump weighs nearly 14 tons, stands 10 ft. high and has 4-ft. dia. Also, that's reason enough to can in metal both the stationary outer coils and the rotor, confining radioactive water within system—Westinghouse Electric Corp., Pittsburgh 30, Pa. 200C

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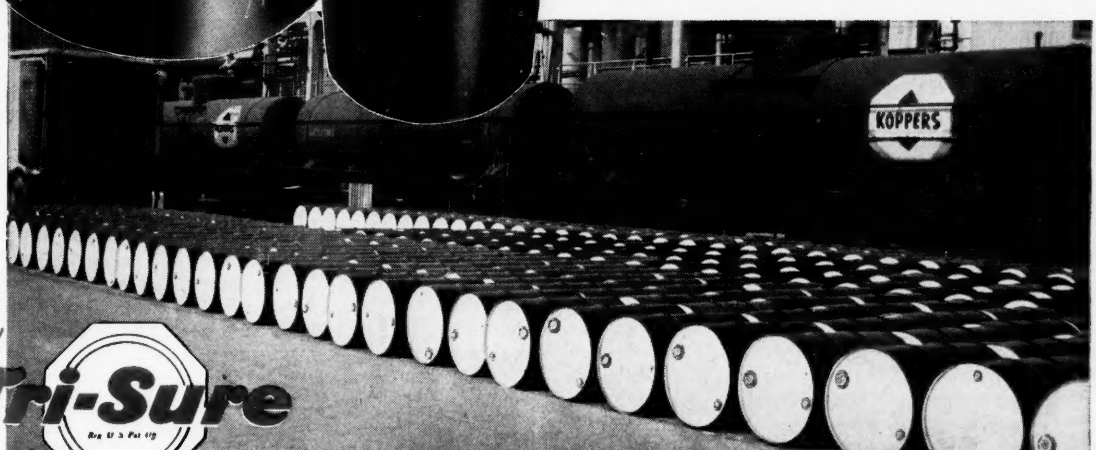

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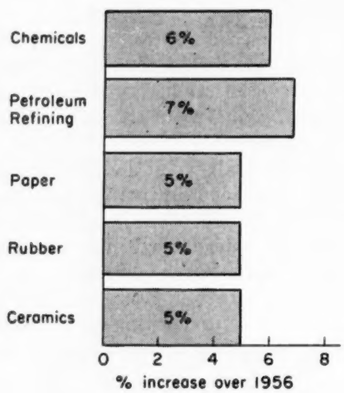
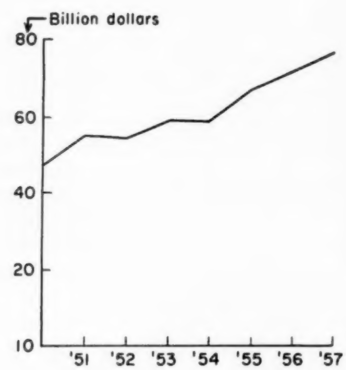
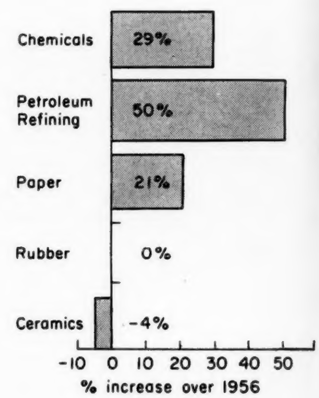
TRI-SURE THE WORLD OVER

In '57 Chemical Processors Will . . .

Make More, Sell More, Spend More







Douglas Greenwald, McGraw-Hill Dept. of Economics

1957 will turn out to be the best year ever for the chemical process industries as they lead the parade of all manufacturing industries in production, sales and in capital spending.

According to recent studies and surveys by the McGraw-Hill Dept. of Economics:*

- Production will be up 6% on the average for the chemical processing industries, compared with an over-all industrial gain of between 3 and 4%. Output of petroleum refiners will be up 7% in 1957; up 6% for chemicals and allied products; and up 5% for paper, rubber and ceramics (stone, clay and glass).
- Sales, at manufacturer's level, of chemical processing industries should top all previous marks by quite a margin in 1957 as they run to more than $76 billion, a gain of 8%. (A year ago we indicated value of output for chemical processing would reach $70 billion in 1956; it actually reached $70.9 billion.)

Sales of chemicals and allied products alone are expected to run about $26.5 billion this year, an increase of $2 billion over 1956's record level. And last year's sales were $1.5 billion over 1955's.

- Capital spending will be jacked up another 23% to $4.7 billion by chemical processing industries in 1957. This increase is much bigger than the one planned by the manufacturing industry as a whole (14%) and is more than double the expected rate of spending gain for all business (11%).

▶ **No Letup in 1958, Either**— McGraw-Hill's survey indicates the capital spending boom by all business is heading for high-level stability. Most companies queried plan to maintain big spending in 1958. No down turn is yet in sight.

This is typical of chemical processing industries, too. Two-thirds of reporting companies plan to maintain or increase their 1957 expenditures in 1958.* More than 40% plan to spend the same in 1958 as in 1957. And at least 24% expect to spend more.

Rubber industry plans are the most optimistic for 1958. Forty-two percent of reporting companies in this industry expect to increase spending next year. In the case of paper firms, 29% expect to increase spending after 1957. Only 26% of chemical and allied products companies anticipate a further increase in capital spending for 1958.

▶ **Chemicals Spend Big** — The Chemical industry plans to spend the most of any manufacturing

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* Two years ago McGraw-Hill's survey said 1955 would be the best year ever for chemical processing industries. One year ago the survey predicted 1956 would be the best year ever. (It was right both times.) Now this year's survey says 1957 will be the best year ever. We're happy to be monotonous.

* Advance plans for these companies do not appear quite as strong as they were a year ago. At that time over 70% of the companies reporting on this question indicated they would maintain or increase spending in 1957.

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How Many Companies Will Spend More in 1958?*

		How Many the Same	How Many Less
Chemicals	26%	37%	37%
Petroleum	17	66	17
Paper	29	25	46
Rubber	42	50	8
Stone, clay and glass	17	43	40
All manufacturing	22	46	32
All business	24	46	30

* As compared with 1957. Percentages based on responses to McGraw-Hill survey.

industry in 1957 for new plant and equipment. Planned figure is $1.9 billion, 29% more than industry spent in 1956.

Petroleum refiners expect to spend more than $1 billion in 1957, a fantastic 50% increase over what was actually spent in 1956. This is the most this sector of the petroleum industry has ever budgeted for refineries and petrochemical plants.

Expenditures for expansion and modernization of pulp and paper mills will be up more than one-fifth in 1957 (to $978 million). Rubber companies, with a relatively poor year behind them because of slower auto sales, plan no increase in capital spending in 1957.

Manufacturers of ceramics are now planning to spend less in 1957 than in 1956. Probable reasons for this decline: Tremendous increase in capacity for this industry in recent years; and the fact that the housing market trended downward in 1956, and may be expected to average even lower this year.

▶ **How High Will Prices Go?**—For the first time, McGraw-Hill's survey asked how much capital goods prices would go up. Chemical, rubber and petroleum companies expect prices of capital goods they buy to be up 6% on the average this year. Paper and ceramics firms look for a 7% increase.

Now these price hikes show that actual physical volume of plant and equipment (equipment which could have been purchased at '56 prices, corrected for increases in those prices for 1957) to be installed by chemical processing industries in 1957 will be up only about 16% instead of 23%.

For chemicals, the corrected increase in capital investment turns out to be only 23%; for paper, 14%; for rubber, −6%; and for ceramics, −11%.

▶ **Production Peak** — Chemical output, as measured by the Federal Reserve Board's index, hit a new peak in 1956, averaging 6% higher than in 1955, itself an all-time high.

Industrial production—output of manufacturing and mining industries—gained only 3% in 1956 as July's steel strike cut into over-all output gains. However, a 3%-4% annual gain in physical output is about the average gain we should expect at these high economic levels. Remember, too, that this increase follows an 11% gain in 1955.

▶ **Everybody Up** — Gross national product—value of all goods and services produced in the nation—is expected to average $435 billion in 1957, compared with $411 billion in 1956. Some of this will reflect price increases. And some will represent the growing volume of services. But physical output is expected to be up, too. Look for the last quarter of 1957 to be the best quarter in the year, with GNP running slightly more than $440 billion.

All sectors of the economy—government, business and consumers—will show an increase over 1956. The consumer and how he spends his income in 1957 may decide whether 1957 is a good year or a really big year.

▶ **Government Digs Deeply** — Government spending in 1957 will be up. Even before shooting around Suez began, defense spending was already budgeted to rise $2 billion over the year. Now it seems possible that defense expenditures will go up even more.

The federal government also plans to spend more on civilian programs this year—the soil bank plan for agriculture, and aid to states for highways and schools. It is now expected that government spending will rise close to $6 billion—half of the rise in federal spending, half in state and local.

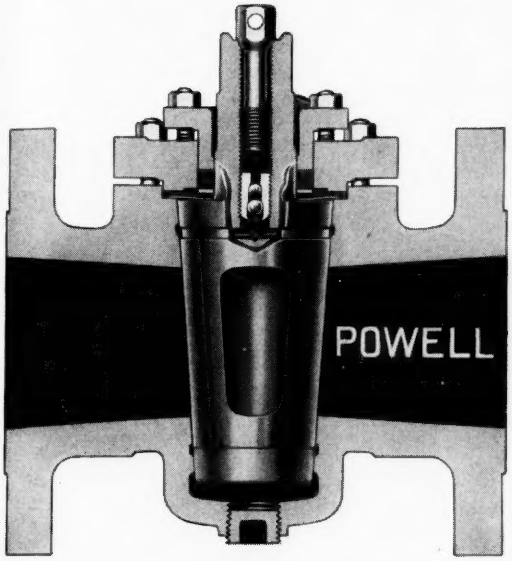
▶ **Ceilings Ahead**—Business investment is going up, too. The McGraw-Hill survey indicates a moderate rise throughout the year. However, this sector of the economy will not provide the spectacular boost it did in 1956. It is just not possible to get enough money either from profits or from the money market to continue such a rate of increase. And we are bumping against ceilings of materials and skilled labor to produce capital goods.

Inventories are not likely to be an important factor in the outlook for 1957. Total business inventories are running about 1.6 time sales, which is just about average for the postwar period. Inventories over the year ahead are not likely to swing decisively one way or the other.

Residential building—part of business investment—will not be a very important factor in the outlook for 1957, either. It cannot go up or down very much from current levels. The potential limit on "down" appears to be one million housing starts. The limit on the upside will be determined by supply of mortgage money and demand for new housing. Both are on the weak side at this time.

▶ **Watch Consumer Spending**—Consumer spending may well be the most dynamic factor in the economy this year. And it is the factor most likely to grow in strength as the year wears on. First incomes are on the rise. Employment promises to be higher in 1957 than in 1956, and many of the wage agreements carry promise for further increases in 1957. A long period

Inside Story on POWELL STEEL VALVES



Steel Valves may appear similar on the outside. But their performance may be quite another story--for there can be a big difference in the metal, in design and in manufacture. And the inside story on Powell Steel Valves is that every valve has PERFORMANCE VERIFIED.

FIG. 3059--(Sectional)--A.S.A. 300-pound Steel Lubricated Plug Valve.

Only the finest materials are used in Powell Steel Valves. And painstaking quality control is rigidly enforced through each step of manufacture. For example, every machining operation is accurately gauged. All parts are thoroughly cleaned and degreased. As a final step in manufacture, EVERY POWELL STEEL VALVE IS GIVEN AN ACTUAL LINE TEST.

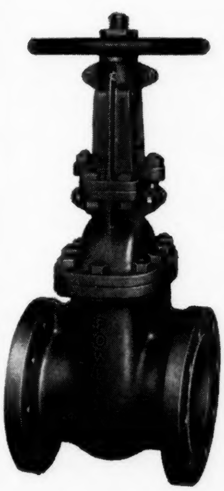


FIG. 2456 SS--OS&Y Gate Valve--1/16 Raised Face Separate Yoke Arms. Flanges are in accordance with ASA B16.5.

Because of Powell's painstaking quality control, plant shutdown through valve failure is practically unknown. Records from refineries, power and industrial plants the world over prove it.

Consult your Powell Valve distributor. If none is near you, we'll be pleased to tell you about our COMPLETE quality line which has PERFORMANCE VERIFIED.

Fig. 2433 SS--Stainless Steel Bolted Cap Swing Check Valve for 150 pounds W.P.

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POWELL VALVES

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of income gains seems sure to mean a rise in consumer optimism and a greater willingness to buy—especially among farmers, auto workers and others who did not do too well in 1956.

Altogether, consumer spending should increase as much as $15 billion this year, even while consumers maintain a high rate of savings. And spending may go up even faster if a real boom materializes in consumer durables.

Another significant point: People are paying off their 1955 debts. This means a new upswing in buying on-the-cuff is possible by the last part of the year.

All this adds up to a big year for industry in general and chemical processing in particular as production, sales and capital investment soar to new heights in 1957.

Chemical Prices Are Getting Fidgity

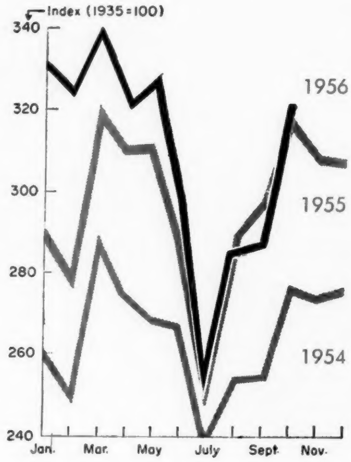
Last year chemical prices were more edgy than they've been in several years. Most people expect them to jump around this year, too. Knowing the areas and extents of price weakness and strength in 1956 gives you a good line on what to expect in 1957.

Actually, over-all wholesale prices for chemicals and allied products were relatively stable even last year, rising only 1% (in first ten months of 1956) as compared to a rise of nearly 3% in prices for "all products other than farm and food," according to Business and Defense Services Administration.

▶ **Long Term Stability** — Chemical price stability goes back further than this, of course: Only 7% higher than 1947-49 base period, compared to a 22% increase for "all manufacturing" prices; and less than 1% higher since mid-1953 vs. 7% for all products except farm and food.

Such uncommon stability is both a reflection of the most intense competition within the chemical industry and a tribute to operational and administrative economies and increased productivity over the years. Last year, however, there were signs that heavy pressures from rising labor and raw material costs, increased charges for transportation and containers, higher interest rates and still-advancing costs of capital outlays and research are beginning to squeeze profits to the point where prices in general must move upward.

Chemical Consumption



Consumption by Industries

	Sept. (Final)	Oct. (Est.)
Coal Products	11.3	11.8
Explosives	11.3	11.4
Fertilizer	56.9	69.0
Glass	21.9	33.2
Iron & steel	19.1	20.2
Leather	4.0	4.1
Paint & varnish	33.7	30.9
Petroleum refining	31.3	30.8
Plastics	23.1	24.5
Pulp & paper	35.3	39.4
Rayon	23.4	27.5
Rubber	6.2	7.4
Textiles	9.6	11.1
Total	287	321

▶ **Ups and Downs**—Here, then, are BDSA figures for 1956 price variations (Sept. 1956 vs. Dec. 1955):

Industrial chemicals—up 2%. Organic chemical prices were up nearly 3%; inorganics, up more than 1%. Essential oils, on the other hand, tumbled 7% due to acute supply-demand imbalance.

Prepared paint—up nearly 3% due to large usage in expanding construction and "do-it-yourself" movement.

Inedible fats and oils—down 2%, a continuation of 45% fall since 1947-49 period. Decline in soapmaking and expanding use of emulsion paints have been prime causes of price weakness.

Drugs and pharmaceuticals—down 4%, a continuation of 51% decline since base period. Mass production, fierce competition are the price-shavers here.

Fertilizers—down more than 9% (nitrogenate prices slipped almost 12%) because of oversupply and competition.

Plastics materials—down 6%. Price declines in plastics are due primarily to competition in polystyrene, general-purpose phenolics and vinyls, as well as lower-priced import offerings of the latter.

Make Your Chemicals In Puerto Rico

That little island group to our Southeast, the Commonwealth of Puerto Rico, is more than 1,000 miles from major markets and raw material sources in the Continental U. S. Nevertheless, there's a healthy young industry, plastics processing, at work there now to the tune of 37 plants and about $10-million worth of products shipped to the mainland in 1956.

Now what's good for plastics processors in Puerto Rico may be good for you even if you are in some other business.

- Federal tax freedom — Since the Commonwealth has no vote in Washington, manufacturers in Puerto Rico pay no federal taxes, hence more than double their net profits. In one recent year plastics makers, on the whole, averaged 16% profits on annual sales.
- Local tax freedom—"Operation Bootstrap," Puerto Rico's industrialization program, excuses a manufacturer from local taxes for ten years after his operations begin. One condition: The new facility on Commonwealth soil must represent a net addition to the mainland company, not a relocated plant. "Runaway" plants, which cause unemployment in the States, cannot share benefits of "Bootstrap".
- Labor supply, large and cheap—Average plastics wage is 67¢/hr.; surplus labor, 100,000 Puerto Ricans.

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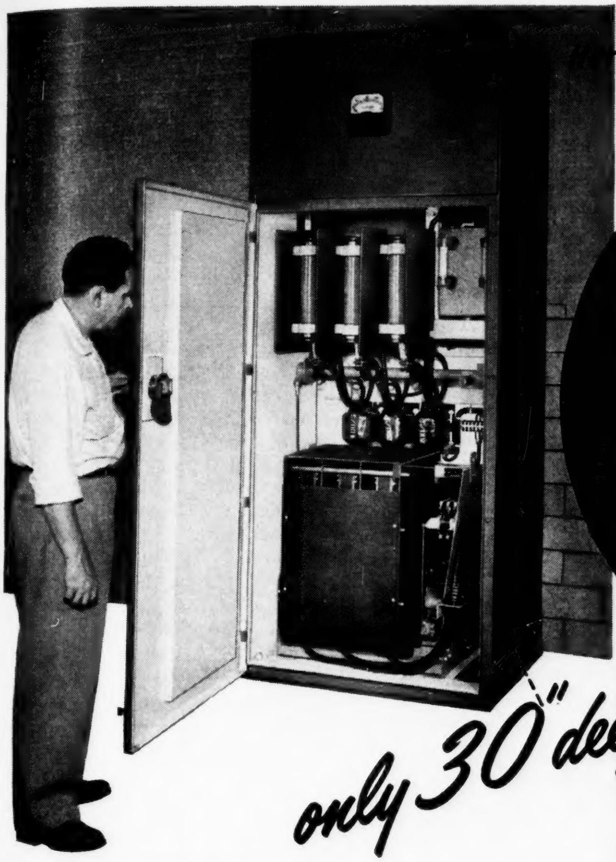

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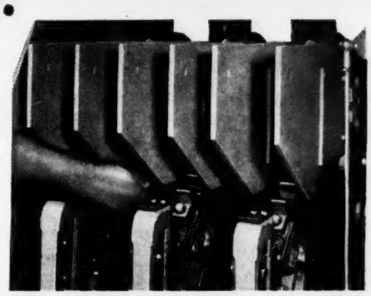

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Partially offsetting these advantages are such factors as high transportation costs, shipping delays and extra inventory to fill long pipelines. But transportation cost may not be the deterrent it at first appears to be. For manufacturers can ship products via boat to Boston, New York, New Orleans, Houston and Baltimore without paying stiff overland freight charges from parent plants on the mainland.

Most finished plastic products shipped by sea from Puerto Rico to the mainland cost 38¢/cu. ft., or $1.10/100 lb. Ocean rates for raw materials range from 38¢/cu. ft., for expanded polystyrene, to 60¢/cu. ft., or $1.49/100 lb., for chemicals.

And you can ship via air to New York for from 10¢/lb. (over 9977 lb.) to 22¢/lb. (less than 100 lb.).—*Modern Plastics*

Slide Those Corporate Tax Rates

Income tax rates based on taxable income—long a bane of the big-money-making individual—are being specifically proposed now as a bromide for small businesses. Let the "ability" to pay determine the corporate income tax rate, say three prominant Democratic Congressmen.

Arkansas Senator J. W. Fulbright proposes to reverse normal and surtax rates (30% of first $25,000 of corporate taxable income, 22% on anything above) and increase the surtax rate to 31% to total 53% and preclude loss of revenue. Under this plan a tax reduction would go to corporations with taxable incomes under $225,000.

Senator John Sparkman of Alabama would set up a series of income brackets with a successively increasing tax rate. This would ease taxation for all corporations making less than $375,000.

Rep. Wright Patman (Texas) offers a bill to extend tax relief to a much higher level: Corporations with taxable incomes of $37 million or less. But firms with the largest earnings would be clobbered to take in the slack. A corporation with $500 million in gross income would pay 20% more tax (or 72%).

Republicans decry all these plans as discriminating against stockholders of large corporations, stockholders who may need dividends as much as those holding shares in small firms. Only solution to tax problems of small business, says one Republican spokesman, is a substantial cut in tax rates across the board.

Profiling the Chemical Processing Industries

Among the myriad industry statistics in the 1954 Census of Manufacturers are figures on employment, payroll, value added by manufacture and capital expenditures for chemical process industries.

We've taken these figures for each industry and reexpressed them in terms of the individual in order to reflect his productivity, his compensation and the investment he represents—and in order to give you a faster insight of the comparative economic character of each industry.

	Employees	Compensation per Employee	Value Added by Manufacture per Employee	Capital Spending* per Employee
Chemicals and products	741,000	$4,600	$12,400	$1,260
Inorganic chemicals	119,000	4,900	10,300	1,880
Sulfuric acid	4,000	4,250	16,200	2,750
Alkalis and chlorine	20,000	4,800	12,600	1,750
Organic chemicals	244,000	4,850	13,000	1,770
Cyclic (coal-tar) crudes	2,000	4,000	11,000	1,060
Intermediate coal-tar products	33,000	5,000	11,000	2,200
Plastics materials	38,000	5,000	14,500	2,900
Synthetic rubber	9,000	5,000	17,000	1,560
Synthetic fibers	61,000	4,300	11,800	1,030
Explosives	32,000	4,600	5,800	530
Drugs and medicines	94,000	4,650	14,200	600
Soap and related products	46,000	4,900	17,800	610
Paints and allied products	71,000	4,600	11,000	420
Gum and wood chemicals	8,000	3,000	8,400	1,000
Fertilizers	31,000	3,450	7,500	1,450
Vegetable and animal oils	40,000	3,800	9,900	1,000
Compressed and liquefied gases	11,000	4,300	10,000	1,820
Insecticides and fungicides	6,000	4,200	10,000	500
Petroleum and coal products	217,000	5,100	11,900	3,500
Petroleum refining	154,000	5,300	12,300	4,250
Pulp, paper and products	529,000	4,200	8,600	1,000
Rubber products	247,000	4,300	7,700	530
Stone, clay and glass products	494,000	3,950	7,700	620
All industries	16,000,000	4,100	7,200	480

* For new structures and additions (including repairs and improvements) to manufacturing plants in operation in 1954.

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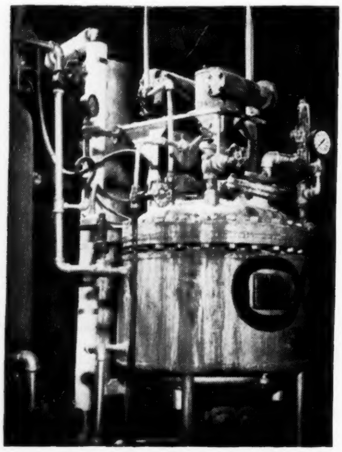
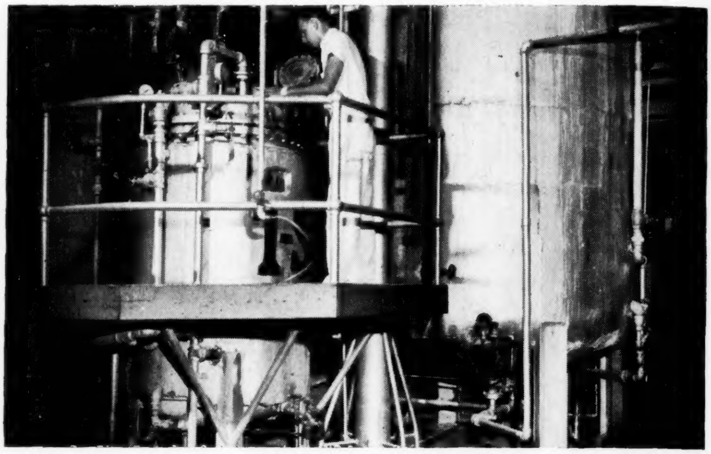




1 **SUBMERGED FERMENTATION: Microorganisms, grown in lab, join nutrients, sterilized air in seed tank. As enzyme output swells, broth feeds to larger seed tank, then to 3,000-gal., internally-cooled agitated tank.**

Flexible Processing Keys Enzymes' Future

Neat scheduling of alternative process routes nets Takamine's wide variety of enzymes under a single roof.

Chemical engineers, prodded by a ground swell in enzyme research, are now beginning to see in industrial enzymes a family of widely effective organic catalysts to add to their workshop of processing tools (see *Chem. Eng.*, Nov. 1956, pp. 122-124).

Predicts one industry observer: "The day is coming when chemical engineers will be reaching for enzyme catalysts with the nonchalance that they now reach for alumina or platinum. When that day comes, the demand will be for a wide variety of enzymes, each tailored to a highly specific processing job."

Industrial enzyme manufacturers are already tooling up for that day. Expanding capacity to meet an expected $100-million/-yr. market by 1965, they're designing top flexibility into their plants to turn out the maximum number of products.

▶ Expansion With Flexibility—Takamine Laboratory, a pioneer in the field, has recently doubled its capacity; the firm now turns out some 30 enzymes and enzyme preparations virtually under a single roof at Clifton, N. J. Using a batch operation only, Takamine processes over 5,000 gal./day of culture liquors. And a company spokesman expects the near future to bring further expansions with an ever-growing product list.

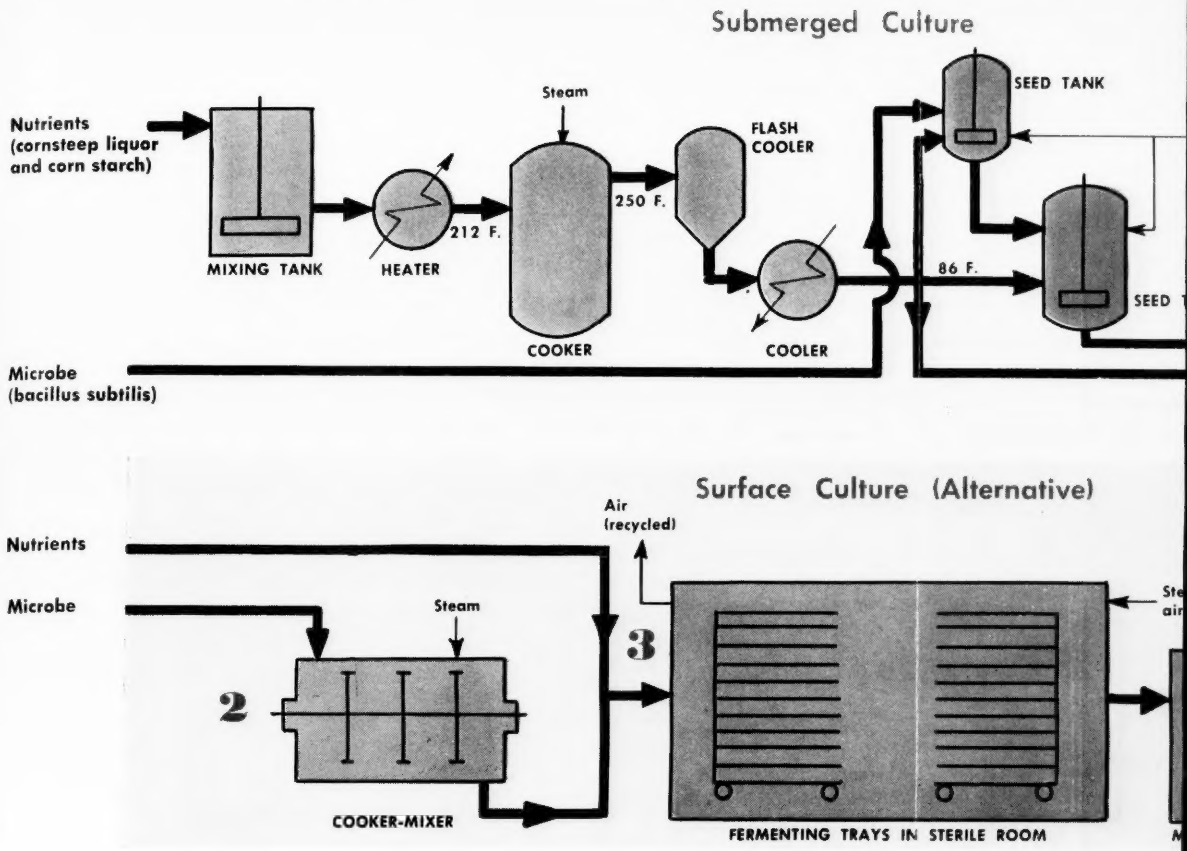
To get its versatility, Takamine includes alternative equipment at each processing stage, right down the flowsheet line. It can start with either submerged or surface microbial fermentation, or with extraction of living tissues. Then to isolate the enzymes, it can run vacuum evaporators, solvent or salt (ammonium sulfate) precipitators. And for top purity, enzymes journey through ion exchange, electrodialysis or other adsorption operations.

Takamine maintains this multiplicity even in its secondary processing equipment. Freeze, shelf and tumbling dryers, vacuum and pressure filters, tumbling and ribbon blenders stand side by side on the plant floor.

▶ Programming for Output—To keep all this equipment in profitable action, Takamine starts two or three enzymes off simultaneously. As the different batches move along, other ensymes take over as equipment becomes available. With the batches neatly criss-crossing each other's path, it's a rare time, Takamine reports, that any equipment stands idle.

Continual alternation of feeds requires that all the equipment be sterilized thoroughly with steam between batches. For any trace of a previous batch could easily start a wild bacterial growth to overwhelm the subsequent batch in a matter of hours. And to resist the corrosive action of various chemicals, Takamine named stainless steel as material of construction, right down to the last pipe fitting.

▶ Submerged Tops—Of its three starting points, Takamine re-



ports, submerged fermentation accounts for better than half its production. And all new expansion is designed around this route. Reason: Submerged fermentation requires the least manpower and space, permits very close control of operating conditions. Microorganisms ordinarily reluctant to work in a deep tank are being schooled to it early in their lab life. Still, some enzymes amenable to submerged processing are scheduled via the surface route in order to make use of equipment available. (Extraction of tissues is used only when no known bacteria will produce a particular enzyme economically.)

▶ **Why Not Continuous?**—The ever-present danger of contamination, Takamine feels, rules against engineering for continuous fermentation; the growth of undesired enzymes could shut down the entire installation. In batch flow, on the other hand, contamination knocks out only a portion of the plant. Too, continuous processing loses the close control needed in production of specific enzymes.

Intent on streamlining batch operation, then, Takamine engineers are improving agitation, aeration and heat-exchange mechanisms, thus tightening their control on reactions for top yield efficiencies. In the lab, researchers are developing harder-working bacterial strains and more-nourishing nutrients for them to feed on.

▶ **Journey of a Batch**—Following the manufacture of a single enzyme—thermal-stable amylase—with some significant side excursions best illustrates Takamine's operations (*see flowsheet*).

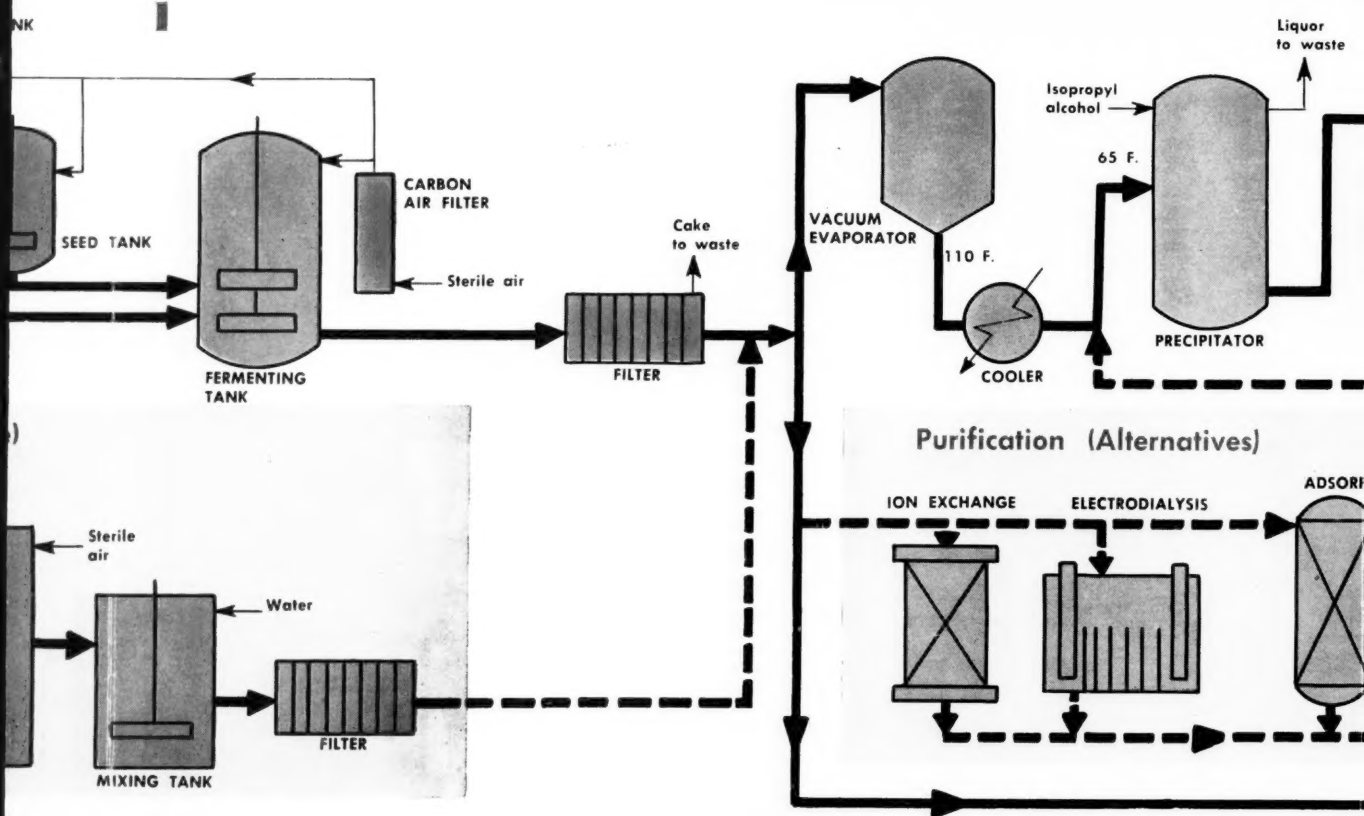
Starting materials are *bacillus subtilis*—the microorganism that produces amylase—and a substrate of cornsteep liquor and corn starch—the nutrients on which the microorganism thrives. Operation can start with either submerged or surface fermentation. Nutrients are mixed, cooked and sterilized apart from the bacteria. Then they are inoculated with microbial spores and introduced to deep tanks or trays.

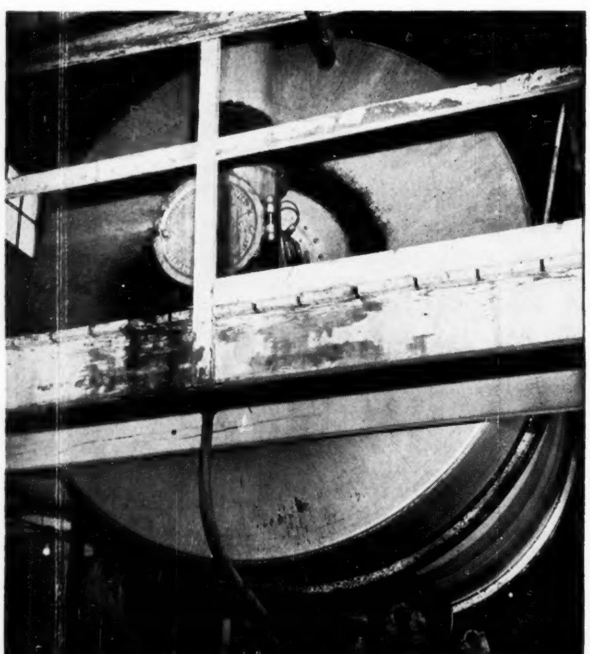
To get a powder product, Takamine precipitates amylase from filtrate of the fermentation broth with isopropyl alcohol as shown. In some instances ammonium sulfate is used. Preservative, activator, stabilizers, etc. are added directly to the filtrate when the enzyme goes to market as a liquid.

When an extra-high-purity product is desired Takamine follows the third alternative route shown on the flowsheet. Amylase solution is selectively adsorbed on silica gel, alumina or ion exchange resins. Frequently electrodialysis is used, and flotation separation is under study. These purification operations are possible because the enzymes, protein in character, behave much like charged ions; the charge depending on the pH of their solution.

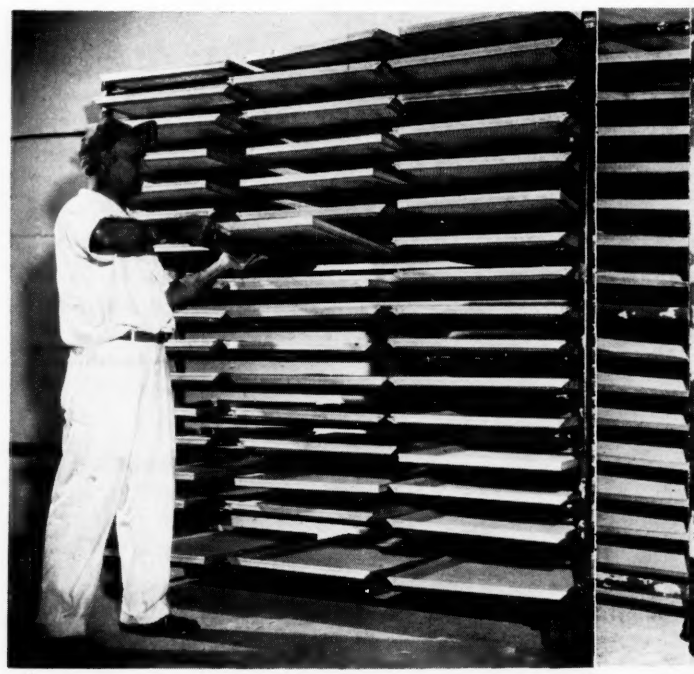

2

1

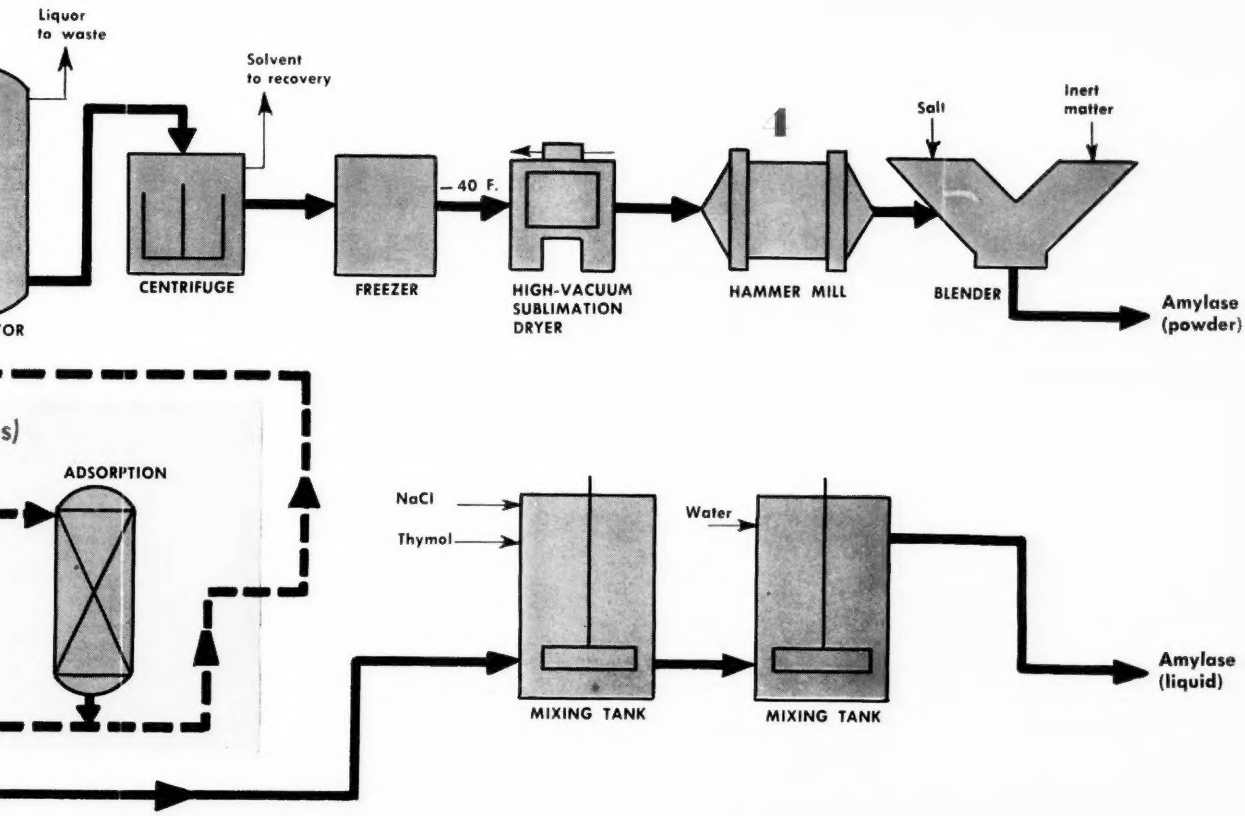


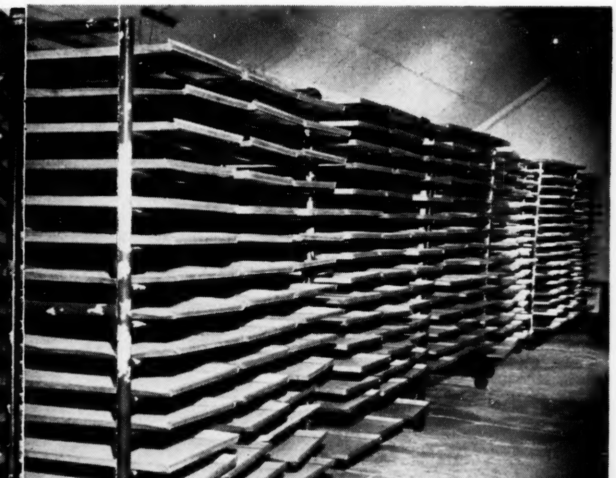


2 **COOKER-MIXER:** For surface route, nutrients are mixed, cooked, sterilized with steam in this drum.

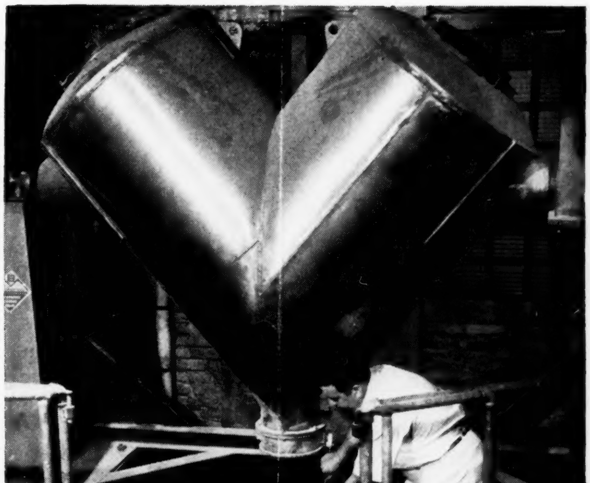


3 **SURFACE FERMENTATION:** Inoculated medium is spread th dollies in a sealed room. Recirculating warm, humidified, sterile

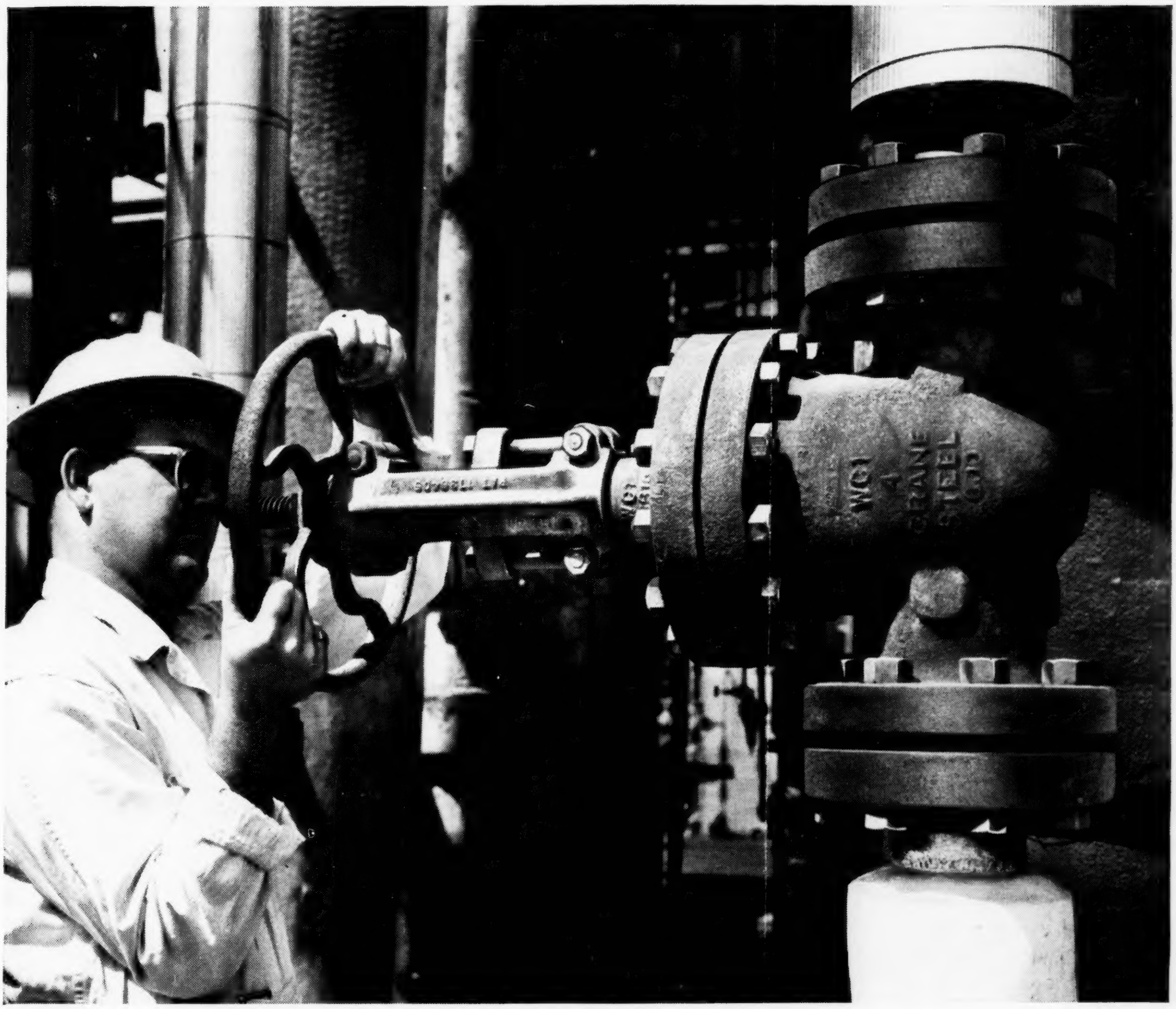




is spread thinly on woven-aluminum screen trays stacked on
ified, sterile air controls the growing conditions.



4 **BLENDER:** Enzyme powder is blended with salt, diatomaceous earth, other enzymes to desired potency.



Two years on high-pressure hydrogen ... no leakage ... no maintenance!

Two years ago, Celanese Corp. installed this Crane valve in their large petrochemical plant in Bishop, Texas. It's a 4-inch No. 76XR 600-pound steel gate valve, on a line to a hydrogenation reactor. Pressure is 800 psi. and temperature 375° F.

What's the maintenance cost story on this valve—after 2 years of such severe service? *It hasn't cost a dime.* Celanese maintenance crews haven't been near it once with a wrench. Leakage? *Zero*—there hasn't been a trace of leakage during the 2 years the valve has been on the line.

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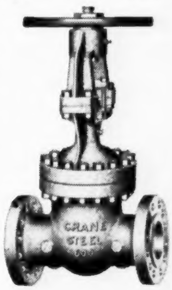

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FEBRUARY 1957

Department Index

BUYERS GUIDE TO STAINLESS

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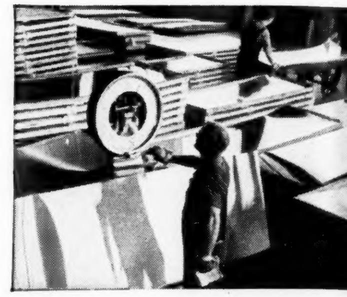
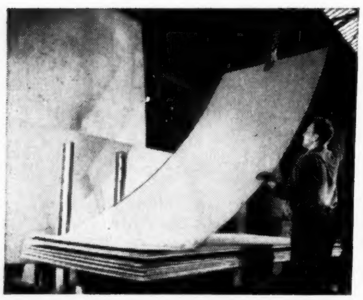
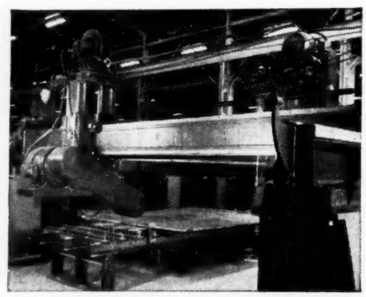
See your Ryerson catalog for a complete listing of stocks and call your nearby Ryerson plant for quick shipment of Allegheny stainless—one piece or a truckload.



SHEETS—11 analyses of Allegheny stainless sheets in stock including nickel and straight chrome types. Also extra wide sheets to reduce welding costs.



PLATES—Available in 9 analyses including plates to Atomic Energy Commission requirements and to ASTM specifications for code work. Also extra low carbon types for trouble-free welding.



TRUE-SQUARE DISC CUTTING—Stainless plates up to 12′ x 25′ cut absolutely square on abrasive disc machine. Length and width tolerance plus or minus 1/32″.

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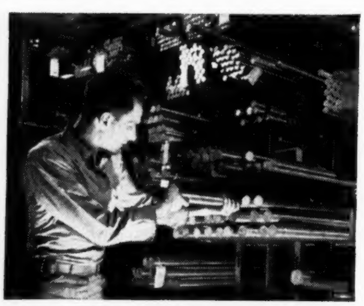

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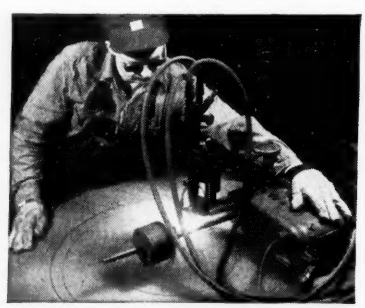

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Chemical Engineering
FEBRUARY 1957

With no reference volumes, no physical data and with nothing but your own slide rule . . .

For preliminary evaluation or for engineering design, here are reliable methods that you can use to . . .

Estimate Engineering Properties

WALLACE R. GAMBILL, Carbide & Carbon Chemicals Co., Charleston, W. Va.*

MODERN chemical engineering concepts involve maximum usage of generalized design correlations. These, in turn, include the variables of system geometry, flow characteristics, thermodynamic properties and physical properties.

For the design of any chemical plant, a tremendous amount of detailed calculation is required. We require calculations in the areas of momentum, mass and heat transfer for a wide variety of materials, many of whose physical properties are generally unknown. As a preliminary to their primary design objective, chemical engineers must determine by experiment, calculation, literature search, experience or intuition, physical-property values that they can use in their design correlations.

Since it's difficult to envisage a time when all property values of all pertinent substances under all conceivable conditions of temperature, pressure and composition will be known accurately from past experimental work, the value of fairly reliable calculation methods for estimating these properties becomes evident.

The estimation approach eliminates, in many cases, the time lag and expenditures connected with experimental work. And it avoids the large errors inherent in the indiscriminate use of past experience or of intuition in totally novel situations. However, this statement does not intimate that many existent rules-of-thumb are not useful in setting orders of magnitude.

Gathered Together for the First Time

This series of articles will try to summarize in an orderly manner the many methods available to engineers who work with these variables. Mechanical and aeronautical as well as chemical engineers should benefit from knowledge of the material under consideration. To those familiar with the concepts to be discussed, it is appalling that so few engineers who could profitably use available correlations are aware of them.

The many contributions that have been made in this field over the past century are so widely scattered throughout the literature that we felt a comprehensive, coordinated compilation would prove useful.

In 1880 only a small number of property estimation methods were known. These had been developed mainly by physicists and physical chemists, usually with a view toward elucidating an extant theory of the structure of matter rather than in providing practitioners of the art with useful tools. The formation of the petroleum refining industry around 1915 provided the first real impetus to formulation of property estimation methods. This movement was furthered around 1925 with the birth of the synthetic organic chemicals industry with its even wider variety of chemical families.

Since the turn of the century, hundreds of articles that deal with this subject have been published. But few engineering books gave more than lip service to this important phase of chemical engineering until Hougen & Watson published "Chemical Process Principles" in 1943.

Correlation work in the past decade reached a fever pitch, so that now very reliable correlations are available for some properties. Moderately accurate correlations are available for others.

The Approach Varies Considerably

Some engineers are devotees of a particular approach to this problem. The approaches of

* Mr. Gambill is now with the Union Carbide Nuclear Co., Oak Ridge, Tenn. To meet your author, see p. 324.

Hirschfelder, Othmer, Driesbach, Eyring and Landee and Whittier, for example, differ considerably. And though each general approach covers a wide part of physical property estimation and each answers many questions, none is complete in itself.

Some approaches are theoretical, others semi-theoretical or empirical; one may be based on simple kinetic theory, another on statistical and quantum mechanics, or on the tenets of the thermodynamics of irreversible systems; still another may use the concepts underlying Cox charts and their infinite points, or of graphical reference-substance plots on log-log paper to obtain straight lines or of the principle of corresponding states. Finally, one system may be restricted to a single state of matter, another to equilibrium properties only, and yet another to one or two homologous series.

To get the most from this welter of diverse information, we must compare, test, combine and intermesh the various approaches to get the greatest possible generality.

Recognize All the Combinations

The practicing engineer encounters all imaginable combinations and agglomerations of phases and compositions. Consider that for the greatest usefulness, each of over a dozen common physical properties should be calculable for each of the following states of occurrence:

Pure Materials	Mixtures	Other Mixtures
Solid	Solid-solid	Solid-liquid
Liquid	Liquid-liquid	Liquid-gas
Gas	Gas-gas	Solid-gas

However, the reader must not imagine that he has at last discovered a panacea and that experimental property determination is no longer necessary. On the contrary, the very basis for the estimation methods themselves is the existence of reliable experimental data with which their results can be compared, and possibly be made to duplicate ever more closely by improved techniques.

Also, present estimation methods for certain properties are not accurate enough for some engineering work, and the experimentalist may be called upon for a reliable answer.

We might note that the Manufacturing Chemists' Assn. has now begun a coordinated study and compilation of the physical properties of organic and inorganic chemicals of greatest commercial importance—that is, those with the greatest annual production rates and sales totals. This study is being conducted by Dr. Rossini and his associates at the Carnegie Inst. of Technology in a manner similar to that used in API Research Project 44 for hydrocarbons and related substances.

However, readers unfamiliar with this field will doubtless be surprised at the accuracy that can often be obtained in the great majority of engineering applications even when starting with a minimum of information.

To prepare for the presentation to be made in these articles, we made an intense and continuing literature search for methods of calculation, both old and new. Then we compared percentage errors for the methods we found. In many cases, tables of average and maximum deviations for a number of widely different substances were already available in the authors' original papers.

If analysis of the papers revealed that their comparisons were reasonably complete and were made with reliable data, we used the authors' estimates of reliability. In other cases, no such work had been done by the author, or in the case of older work, comparison with newer and more reliable data yielded somewhat different error estimates. In these instances, we used the derived or changed error estimates for comparison purposes.

We had to establish certain lines of demarcation. We considered only intrinsically physical properties. Thermodynamic properties have been treated in great detail in many places and results have been well summarized by such authors as Dodge, Hougen and Watson, Edmister and others. Therefore, we decided not to include them here.

No particular sequence has been assigned to the order of appearance of the articles; it is intended that each section or group of articles on a particular physical property be a useful summary of practical methods for estimating that property for various states of matter.

Where information is available, three main aspects of estimation are treated: determination of a property at a point condition; change of a property with change in conditions; and estimates for mixtures. No experimental data are recorded other than those (such as critical constants) that can be used in estimation methods.

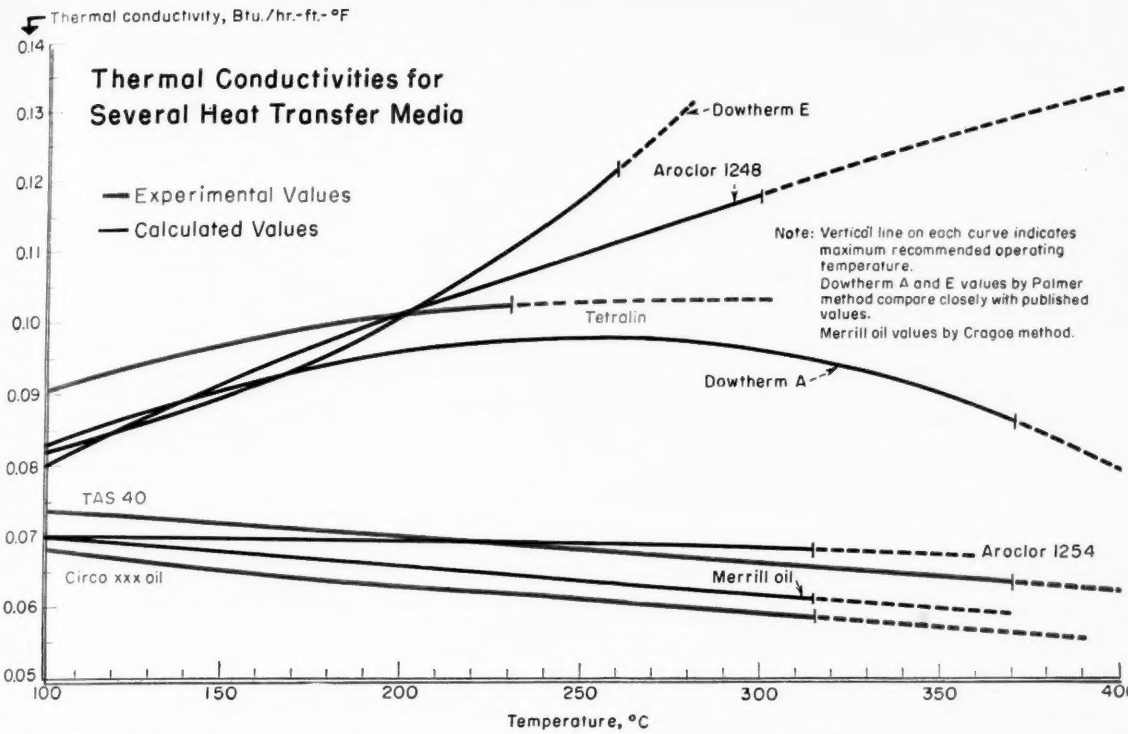
Where There Are Several Methods

In certain sections, several excellent methods are available, from which it is difficult to select the one most suitable for all conditions.

Our plan is to at least allude in each section to all pertinent correlations that we have found, and in general, we'll present them in their order of accuracy or utility. In several places correlations with strictly limited applicability are given, but in each instance the limitations are stated.

Variable interchangeability might also be considered by the reader. For example, an equation ordinarily used to calculate the thermal conductivity of liquids and including molecular weight, might be transposed and used to approximate molecular weight if thermal conductivity is known. There are many such combinations. Formation of these combinations is generally left to the reader, but a few particularly useful examples are suggested.

This series is a greatly expanded and updated version of a booklet which was prepared by the author in early 1953 for use by the engineering department and other interested personnel of the Carbide & Carbon Chemicals Co.



ESTIMATION METHODS described below and in succeeding installments will help you to . . .

Predict Thermal Conductivity—I

Frequently required for design calculations, thermal conductivities are scattered through the literature. Now you can avoid the tiring search and calculate reliable values from basic fundamentals.

WALLACE R. GAMBILL, Chemical Engineer, Oak Ridge, Tenn.*

Thermal conductivity values are frequently required in engineering work for heat transfer calculations where they enter into heat conduction equations and the Prandtl number, $C_p\mu/k$.

For the vast majority of liquids, especially those of an organic nature, the range at ordinary temperatures is 0.05 to 0.20 Btu./hr.-ft.-°F., with 0.08 a good average which might be used without too large an error for almost any organic (*see chart above*). For liquid metals the range is broader, approximately 5 to 50 in the same units.

Water is an exception (as shown in Fig. 1 on the next page), having a maximum value of 0.398 at about 130 C. with a positive temperature coefficient below and a negative one above this temperature. Liquid CO_2 and Dowtherm A exhibit similar maxima in their conductivity-temperature curves; but this behavior is an exception. Most liquids decrease in conductivity with increase in temperature.

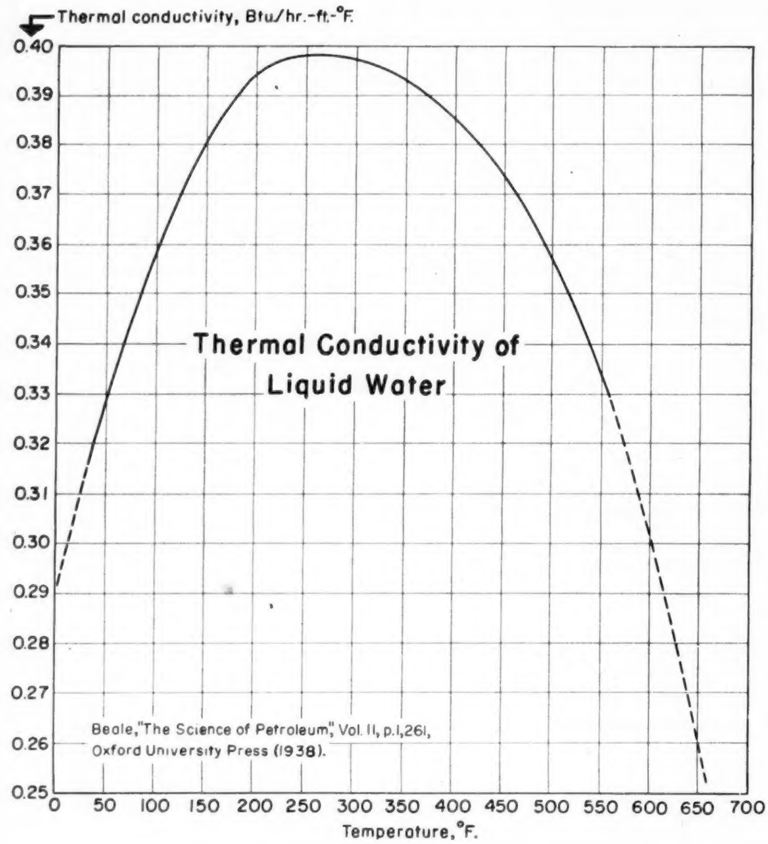
As we might expect, the conductivity of aqueous solutions in general decrease with increasing solute concentration at a given temperature, because of the unusually high thermal conductivity of water.

The influence of molecular weight on conductivity is not clear cut. A plot of k vs. M for a series of compounds of various types shows a succession of sharp minima and maxima, indicating that more than molecular weight is involved.

Even with a homologous series such as the normal paraffins, there is no consistent trend of conductivity with molecular weight.

The existence of many variables of which thermal conductivity appears to be a function on a macroscopic scale has made its prediction difficult. Most methods have evolved on a semi-empirical basis. The best of these have attained more success than the smaller number that are derived along strictly theoretical lines. This gives further evidence to the observation that though great strides have been

* See footnote on p. 235.



made in recent years in the molecular theory of fluids, quantitative agreement is far better for gases—and even crystalline solids—than for the liquid state. We usually consider the liquid state to be some sort of scrambled solid or highly compressed gas.

A Scattered Literature

Experimental values of thermal conductivity are scattered throughout the literature, and the critical survey made by Sakiadis and Coates[1] is a welcome addition to our physical data files. If a desired conductivity value cannot be found in this compilation, or in the literature since 1952, it will probably have to be estimated by means of the methods outlined below.

You should bear in mind that some values reported in the literature, due to experimental difficulties such as natural convection currents, are doubtless in error by as much as 20%. An estimate of the experimental errors involved is made in the Sakiadis and Coates compilation. *(See Ref. 1 at the end of this article.)*

The effect of pressure on the thermal conductivities of liquids is fairly small, and is partially taken into account in the following relations by the effect of pressure on the included variables such as specific heat and density. Test data on 28 liquids[2] has shown that a pressure increase from 1 to 2,000 atm. increases the conductivity by an average amount of only 13% (range of 11.1 to 15.3%); an increase to 12,000 atm. brought about a conductivity increase of approximately 100%.

These data may be generalized so as to state that for a reduced pressure of about 40 and a reduced temperature between 0.5 and 0.7, a 13% increase of conductivity above that at 1 atm. may be expected.

We can recommend an excellent paper for those who want a deeper insight into the physical mechanisms of thermal conduction in matter. See Ref. 3 by L. S. Kowalczyk.

Methods for Pure Liquids

In this article and next month's installment we plan to present several methods for the estimation of thermal conductivity of pure liquids. Later articles will discuss mixtures, solids and gases.

Method 1—Sakiadis and Coates

Sakiadis and Coates[4] have recently proposed a fairly complex method for computing, with high accuracy, the thermal conductivities of both normal and associated liquids. When applied to the best data for 42 pure organics, average and maximum deviations of plus or minus 2.6 and 6.0%, respectively, were obtained.

The equation is simple in appearance, being identical in form to that of Kardos,[5] but since the intermolecular distance term, L, is interpreted differently, the equation is much more successful. While Kardos assumed L to be a constant, Sakiadis and Coates realized that it varies with the nature of the liquid and with temperature (approaching zero as the absolute temperature approaches zero).

A molecular arrangement in the liquid is assumed and L is taken as the distance between molecular surfaces. The equation is:

$$k = C_p \rho L U_s \qquad (a)$$

where k is in Btu./hr.-ft.-° F.; C_p is in Btu./lb.-°F; ρ is in lb./cu. ft.; L is the intermolecular separation in ft; and U_s is the acoustic velocity in the liquid in ft./hr.

Density and heat capacity are obtained from experimental data or calculated or extrapolated by methods treated elsewhere in this series. The acoustic velocity, U_s, is calculated by the method of Rao[6]:

$$U_s = (R \rho / M)^3 \qquad (b)$$

where U_s is in ft./sec.; ρ is in lb./cu. ft.; M is the molecular weight; and R is a constant for a given compound.

The constant R is an additive, temperature-independent function similar to the parachor or molecular refraction. Sakiadis and Coates have, after extensive comparisons with experimental data, made two revisions of the atomic and group contributions originally specified by Rao. When these latest constants, shown in the boxed table,[4] were used for a comparison with 135 pure organic liquids of many types, both normal and asso-

ciated, average and maximum deviations of plus or minus 2.6 and 8.0%, respectively, were found.

The relative complexity of this method enters with the calculation of L. If the neighboring molecules are considered to possess rectangular shapes,

$$L = x - d \qquad (c)$$

where L is the surface-to-surface separation; x is the center-to-center separation; and d is the diameter or width of an individual molecule.

Molecular diameter, x, in Angstrom degrees can be found from a table prepared by Sakiadis and Coates. Space does not permit us to reproduce this table here. We refer the interested reader to the *AIChE Journal,* 1, p. 287 (1955). This table covers the bulk of the literature data for X-ray diffraction measurements. The estimated accuracy is plus or minus 0.05 Angstrom units.

It can be shown that:

$$d = (v_o \rho N x^2/M)^{0.5} \qquad (d)$$

where v_o is the minimum molecular specific volume; ρ is the density; M is the molecular weight; and N is Avogadro's number, 2.73×10^{26} molecules/lb.-mole. So that,

$$L = x[1 - (v_o \rho N/M)^{0.5}] \qquad (e)$$

The minimum volume term, v_o, may be calculated to within about 2% from a relation based on the law of rectilinear diameters. The equation is applicable to both normal and associated liquids:

$$v_c/v_o = \rho_o/\rho_c = 2\left[1 + \left(\frac{0.5\rho_F - \rho_c}{T_c - T_F}\right)\left(\frac{T_c}{\rho_c}\right)\right] \qquad (f)$$

This ratio, which is usually about 4, as predicted from Berthelot's equation of state, may be combined with Eq. (e) to give the final over-all expression for the intermolecular surface separation:

$$L = x\left[1 - \left(\frac{\rho}{2\rho_c + b}\right)^{0.5}\right] \qquad (g)$$

where b represents the expression

$$\frac{T_c}{T_c - T_F}(\rho_F - 2\rho_c)$$

and where L is in ft.; x is in ft.; T_c and T_F are the absolute temperatures of critical and freezing points in deg. K. or deg. R.; ρ, ρ_c and ρ_F are densities in any units at the given temperature, at the critical temperature and at the freezing point, respectively.

Densities should be extrapolated to the freezing point, when necessary, by the Watson expansion-factor method.[7]

Thus, by using two tables (one here and one in the original reference) and Eqs. (a), (b) and (g), we can calculate the final thermal conductivity values from basic information.

This method is the most general and accurate available today. But it's more lengthy than some of the methods that follow.

Method 2—Palmer

For both associated and nonassociated liquids, Palmer[8] found a relation that gives values that agree with experimental measurements on 47 liquids of various types with an average deviation of 8.8% and a maximum deviation of 27%. The mean deviation for the associated liquids studied was only 5.5%.

Palmer wrote his equation in this form:

$$k = 41.2C_p\left(\frac{s^{1.33}}{M^{1.33}}\right)\left(\frac{T_b}{\Delta H_v}\right) \qquad (a)$$

where k is in Btu./hr.-ft.-°F.; C_p is in Btu./lb.-°F.; s is specific gravity; M is molecular weight; T_b is the normal boiling point in deg. K.; and ΔH_v is the latent heat of vaporization in Btu./lb. at the normal boiling point.

Palmer brought these two classes of liquids, associated and nonassociated, within the scope of a single equation by including the entropy of vaporization (Trouton's constant) as a factor to correct for the presence of hydrogen bonding.

This method appears to be the most general and useful of those presently available. It should be used in preference to other methods described below when C_p, s, T_b and ΔH_v are known or can be estimated accurately.

Method 3—Smith's 1936 Equation

Smith[9] proposed two entirely different empirical equations for nonmetallic (dielectric) liquids at 86 F. only.

The first equation, proposed in 1930, fit all of the meager data then available for some 15 liquids with reasonable accuracy (plus or minus 6%). But upon testing this equation with newer and more accurate data in 1936, Smith found poor agreement and proposed another equation of entirely different form. This 1936 equation checked the experimental data then available for 46 compounds within 6.7%, with a 25% maximum error for glycerine. The error for all other substances was within 16%.

When the 1936 equation was checked[8] with the latest data available for 36 liquids, an average deviation of 8.4% was found. Therefore, at a temperature of 86 F. Smith's 1936 equation is as accurate as Palmer's, though more complex for computation.

Smith's 1936 equation appears in this form when changed to English engineering units:

$$k \text{ at } 86\text{ F.} = 0.00266 + 1.561(C_p - 0.450)^3 + \frac{(s/M)^{0.333}}{3.31} + \frac{(\mu/s)^{0.111}}{41.3} \qquad (b)$$

The 1930 Smith equation was in this form:

$$k \text{ at } 86\text{ F.} = 0.196\,\frac{s^{2.15}C_p^{1.55}M^{0.192}}{\mu^{0.12}} \qquad (c)$$

where μ is the viscosity in centipoises; and all other units are as given above for Eq. (a). Specific gravity, specific heat and viscosity should all, of course, also be at 86 F.

Dick and McCready[10] found that Eq. (b) checked their experimental results for 19 high-molecular-

Structural Contributions to the Velocity of Sound (Ref. 4)

Basic Radicals	**R**
Methyl	9.50
Benzene	23.25
Cyclohexane	27.50
Naphthalene	33.67
Additional Radicals	
Carbon with zero to three hydrogens	4.47
Carbon, two oxygens	6.25
Carbon, oxygen, hydrogen	2.30
Ketone	4.47
—NH—	3.27
$—NH_2$	2.45
—COOH	4.83
—CN	4.20
—O—	1.40
—OH	0.70
—Cl	3.13
—Br	3.55
—I, $—NO_2$	4.58
—S, =S	2.82
Bonding	
Double	−1.30
Triple	−2.60
Position	
Ortho	0
Meta	0.30
Para	0.60

weight organic compounds much better than Eq. (*c*). Bates,[11] however, in a study of the thermal conductivity of liquid silicones with molecular weights as high as 26,400, found poor agreement with both equations. This was particularly the case for the higher viscosities and molecular weights, but with Eq. (*c*) indicating more accurately the viscosity at which the thermal conductivity of a given silicone reaches a maximum.

The experimental values for the silicones fell about halfway between those given by Eqs. (*b*) and (*c*).

Method 4—Weber

The earliest relations connecting thermal conductivity with other physical properties were those of Weber.[12]

His original empirical expression, $k/C_p s$ = a constant, was later modified to:

$$\frac{k}{C_p s}\left(\frac{M}{s}\right)^{0.333} = \text{Constant}$$

leading to,

$$k = 0.869 C_p \left(\frac{s^{1.333}}{M^{0.333}}\right)$$

with all units the same as those used by Palmer in his equation.

Note that the factor $(M/s)^{0.333}$ is proportional to the mean intermolecular separation.

Also, the constant of this equation was later modified by Smith[9] so that:

$$k = 1.041 C_p \left(\frac{s^{1.333}}{M^{0.333}}\right)$$

This equation is simplest and easiest to use of all and checks surprisingly well with experimental data. Smith[9] obtained an average error of 14.8% for 46 liquids. However, values so calculated for normal liquids will be consistently low, and for associated liquids consistently high.

It was this equation into which Palmer[8] introduced the entropy of vaporization to bring the two classes of liquids into reasonable agreement with one another.

Since this relation gives a 28% maximum deviation—and because of its simplicity—we have assigned different constants to various classes of liquids with the following results:

- For alcohols and glycols with the OH group present, the constant 0.871 gives a maximum deviation of 15%.
- For plain aromatic and paraffin hydrocarbons, the constant 1.239 gives a maximum deviation of 8.5%.
- For halogenated or oxygenated hydrocarbons, aromatic or aliphatic, the constant 1.032 gives a maximum deviation of 25%.

We can see that the Weber procedure still leaves something to be desired in accuracy.

Method 5—Bridgman's Equation

Bridgman[2] in 1923 proposed a theoretical, dimensionless equation containing no empirical constants which gives fair agreement with experimental data. Maximum deviation was from −13 to +38% for 11 liquids that Bridgman included in his study.

Bridgman's work was independent of, but generally similar to that of Paschki,[13] who was the first to base a theory of heat conduction in liquids on the supposition that heat transfer occurs by longitudinal molecular vibrations similar to the propagation of sound. Paschki's equation indicates that the thermal conductivity of liquids is proportional to the velocity of sound in the liquid and to the 4/3 power of the density. Dick and McCready[10] found errors as high as −48% for their series of organic liquids.

The Bridgman equation is in this form:

$$k = 2RV_a/d^2$$

where R is the universal gas constant in heat units; V_a is the velocity of sound in the liquid; and d is the mean distance of separation of centers of the molecules.

If we assume a cubical arrangement on the average for the separation of the molecules, we can estimate d this way:

$$d = (m/s)^{0.333}$$

where m is the weight of one molecule; and s is the specific gravity of the liquid. Combining, we get the final equation:

$$k = 2RV_a(s/m)^{0.667}$$

While m is easy to determine from the molecular weight and Avogadro's number, the acoustic velocity must be known or calculated from the compressibility of the liquid. This calculation may be made with procedures outlined by Kincaid and Eyring[15] or Tsien.[16] An excellent summary of experimental values was made by Sakiadis and Coates.[14]

This bulletin by Sakiadis and Coates includes a review of some dozen or so methods for estimating acoustic velocities.

However, because of this extra step the Bridgman method—noteworthy as it is—is not suitable for engineering calculations. We'd like to note that Kardos[5] modified Bridgman's theory by taking into account molecular size. But it appears that the Kardos equation is little better than the Bridgman for engineering use.

In accounting for molecular size, Kardos used the distance between adjacent molecules rather than the distance between their centers. His resulting equation includes a term, L, the distance between molecular surfaces. Using a semi-empirical method for L, Kardos reduced deviations for a group of alcohols to 5% or less. However, this method is not general enough for indiscriminate use.

More Methods Next Month

Next month we'll continue with some more methods that will help you predict thermal conductivity for pure liquids. Then, we'll go on to prediction methods for various mixtures.

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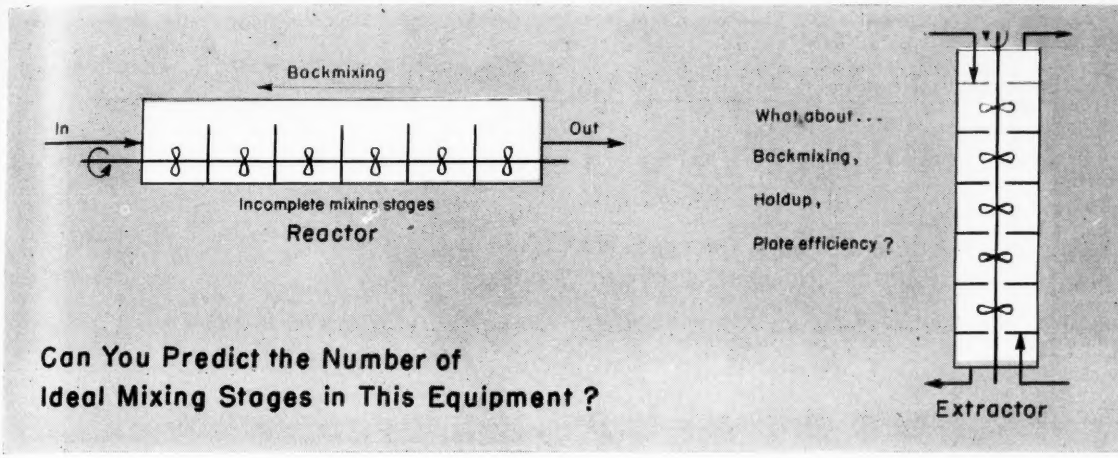


New Tool Analyzes Mixing Stages

Although we know quite a bit about the effect of backmixing in reactors and other chemical process equipment, until now we've had no good way to measure it. Now, here's a new measuring tool for you to consider.

EARLE F. YOUNG, Jr., Jones & Laughlin Steel Corp., Pittsburgh, Pa.*

In this article we'd like to present a new approach to the problem of backmixing in reactors and other chemical process equipment. We think that this approach can be used as the basis for a quantitative description of the backmixing characteristics of process equipment in general.

Our proposed method is a new analytical tool and an extension of equations developed by Kandiner.[1] It should help in the design and analysis of reactor systems and should permit a more accurate definition of the operation of other equipment.

Particular applicability should be found in the case of baffled, agitated extractors such as the Mixco (Mixing Equipment Co.) described by Rushton and Oldshue,[2] or the RDC column developed by Shell and described by Reman and Olney.[3]

A continuous reactor may be longitudinal, such as a single tube, or it may be one or more completely mixed vessels. Both of these reactor types have been analyzed by Jenney[4] and others. But many commercial reactors are partially mixed, an example being a baffled tank or tower (*see sketch above*) in which mixing takes place but not in nicely isolated sections. It is this type of reactor that we'll try to define in terms of equivalent completely mixed stages.

Kandiner has shown how the effluent from the n-th equal vessel in a series varies with time after a change in feed:

$$y_n = 1 - e^{-Ft/V} \sum_{i=1}^{i=n} \frac{1}{(i-1)!} \left(\frac{Ft}{V}\right)^{i-1}$$

It is proposed that in a partially mixed vessel of volume Vo, the behavior approaches that of a number, N, of smaller vessels each of volume Vo/N. Then the effluent will have the characteristics of the N-th vessel. If we can define N for the system, we can predict the behavior of the system analytically.

We have injected this premise into Kandiner's equation. Substituting Vo/N for V, we get the following expression:

$$y = 1 - e^{-NFt/Vo} \sum_{i=1}^{i=N} \frac{1}{(i-1)!} \left(\frac{NFt}{Vo}\right)^{i-1}$$

in which Vo is the total volume of the system, F and t are characteristics of the flow; and the new variable, N, is an expression for the degree of backmixing.

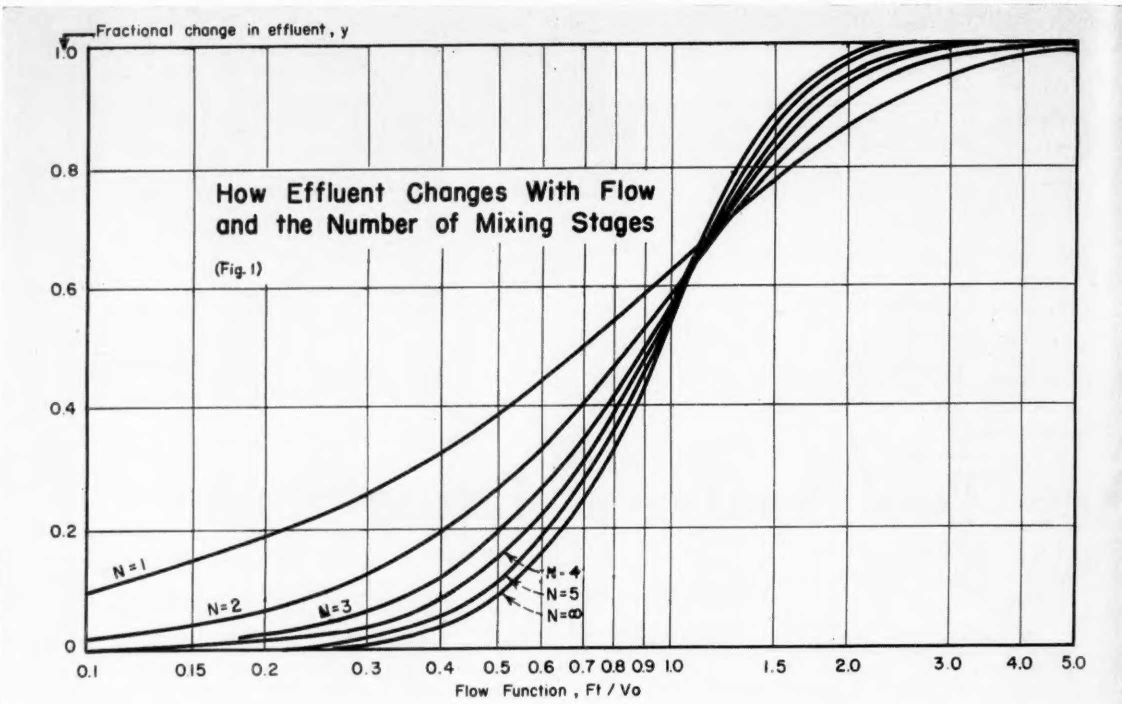
We have plotted this equation (see next page) for $N = 1$ to $N = 5$. The plot is for y as a function of Ft/Vo. Also included is the curve for $N = \infty$, i.e. a perfect longitudinal reactor in which no backmixing takes place. The second, smaller plot is a useful cross-plot of values of y as a function of N with Ft/Vo as a parameter at values of Ft/Vo where there is a considerable spread of y values.

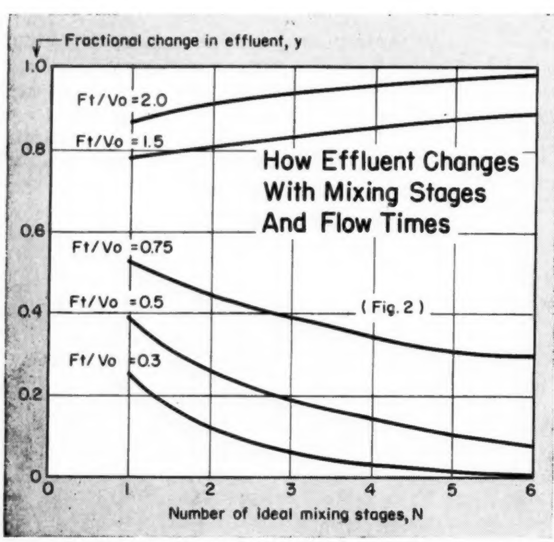
Consider how this evaluation of backmixing might

Nomenclature (Consistent Units)

e	2.7183
F	Flow rate
N	Number of ideal-mixing stages
t	Time
V	Volume of one vessel
Vo	System volume
y	Fractional change in composition where original change = 1.0

* Meet your author on p. 326.





be used. Assume that we want to know how a reaction will take place in a baffled stirred reactor. It's obvious that there will be some mixing so that the reactor will not be perfectly longitudinal. But the mixing will not necessarily be equivalent to any integral number of completely mixed stages. Some extraneous flow between stages will occur.

By making some measurable change in feed (a change from water to a known salt solution, or from clear liquid to a known dye solution) we can get measurable change in effluent. Measuring this change y as a function of Ft/Vo we can, through the use of the plot above, relate this to N equivalent ideal-mixing stages. Then we can use the methods of Jenney, Lessells or others to predict operation for the N-stage system.

Now consider this treatment applied to an extractor. In this extractor there are again a number of compartments but there is backmixing between compartments. In the case where flow of one of the fluids is small, the holdup may be appreciable as compared to net flow.

One method of calculation is to consider each stage as being uniformly mixed and calculate Murphree efficiencies and K_{La} values for the column on that basis. But experimental evidence suggest that backmixing may cause apparent discrepancies in these data.

Actually, two variables, mixing and extraction efficiency, are involved. By analyzing for the number of ideal-mixing stages, then calculating extraction efficiencies on this number of stages, we may achieve a better understanding of the operation. Here, the volume of holdup of the slow-flowing phase may be used for Vo and again N can be calculated from dye tracer or similar data.

We want to emphasize that we have as yet no data on the utility of this method of analysis. It is presented here only as a tool to be used in the solution of some complex chemical engineering problems.

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Use "K's" to Speed Flow Calculations

"K" factors from tables here enable you to use inconsistent units for Reynolds number, viscous and turbulent flow and orifice calculations.

Conventional formula for Reynolds number is $DV\rho/\mu$

Here you must use consistent units such as . . .
$D =$ ft.
$V =$ ft./sec.
$\rho =$ lb./cu.ft.
$\mu =$ absolute viscosity, in lb./sec. ft.

Safer and faster formula for Reynolds number: $KQ\rho/\mu D$

With the author's tables for K, you can use units such as . . .
Q in gpm., cu.ft./hr. or cc./sec.
ρ in lb./cu.ft., grams/ml. or specific gravity
μ in centipoises.
D in inches or mm.

ALFRED H. McKINNEY, Chemical Engineer, Chester, Pa.*

Elimination of errors and improved accuracy result when you use this simplified approach to the arithmetic of fluid flow calculations. You can easily compute Reynolds numbers by this method, as well as pressure drop or flow through pipes under viscous or turbulent flow conditions. The method is useful too for orifice flow. Furthermore, in using the constants presented in the tables, your data can have mixed dimensions, without need to convert to consistent units.

The experts who regularly calculate pressure drops, orifice sizes and similar problems in fluid flow have no doubt mastered the difficulties of converting feet to inches, centipoises to foot-pound units, gallons to cubic feet. Others who make such computations rather infrequently are likely to make mistakes or be confused.

It has seemed useful to calculate, once and for all, the factors appropriate for various combinations of units that frequently occur in practice. These factors allow the estimation of Reynolds numbers, as well as pipe pressure drop or orifice plate calculations, to be made without bothering to change units. Thus any combination such as flow rate in pounds per hour and density in grams per milliliter may be used.

Reynolds number N_{Re} is:

$$N_{Re} = DV\rho/\mu \tag{1}$$

and is dimensionless for consistent units such as D, diameter in ft.; V, average fluid velocity, fps.; ρ, fluid density, lb./cu.ft.; and μ, absolute fluid viscosity, lb./sec.ft.

By the insertion of a suitable constant K any desired combination of dimensions may be used for the variables D, V, ρ, and μ. For example,

$$N_{Re} = 6.315\ W/DZ = KW/DZ \tag{2}$$

where W is flow, lb./hr.; D is diameter, in.; and Z is viscosity, centipoises. In this instance

$$K = \frac{4}{\pi} \times 12\,\text{in./ft.} \times 1{,}488\,\frac{\text{lb./sec.ft.}}{\text{centipoise}} \times \frac{1}{3{,}600}\,\frac{\text{hr.}}{\text{sec.}}$$

$$K = 6.315\,\frac{\text{in. lb. hr.}}{\text{ft.}^2\,\text{sec.}^2\,\text{centipoise}}$$

However, such a heterogeneous combination of dimensions has no real significance. The actual dimensions that the various K numbers have is not indicated in the tables.

Tables I*a* and I*b* give the values of K to calculate Reynolds numbers. Values for flow rate, fluid density and pipe diameter are given in dimensions that are generally useful. Viscosity is always expressed in centipoises.

* Meet your author, p. 319.

Reynolds Number *K*-Values for Volumetric Flow—I *a*

Equation: $N_{Re} = KQ\rho/\mu D$

Dimensions: Absolute viscosity μ = centipoises

Example: Reynolds Number = $378.91 \dfrac{\text{(cu. ft./min.) (lb./cu. ft.)}}{\text{(centipoises) (in.)}}$

Q	D	K, When ρ is expressed in units of:			
		Lb./cu.ft.	Grams/ml.	Specific Gravity 20/20 C.	
				Water = 1.0	Air = 1.0
Gpm.	in.	50.635	3,161.0	3,151.7	3.7437
Cu.ft./hr.	in.	6.315	394.23	393.32	0.46691
Cu.ft./min.	in.	378.91	23,654	23,585	28.015
Cu.ft./sec.	in.	22,735	1,419,300	1,415,100	1608.9
Liters/min.	in.	13.381	835.34	832.87	0.98934
Cc./min.	in.	0.013381	0.83534	0.83287	9.8934×10^{-4}
Cc./sec.	in.	0.80286	50.120	49.973	0.059360
Cc./min.	mm.	0.3399	21.219	21.157	0.025131
Cc./sec.	mm.	20.393	1,273.1	1,269.3	1.5078

Reynolds Number *K* . . . for Weight Flow—I b

Equation: $N_{Re} = KW/\mu D$

Dimensions: Abs. viscosity μ = centipoises

Example: Reynolds Number = $378.91 \dfrac{\text{(lb./min.)}}{\text{(centipoises) (in.)}}$

W	D	K
Lb./hr.	in.	6.3153
Lb./min.	in.	378.91
Lb./sec.	in.	22735
Grams/min.	in.	0.83534
Grams/min.	mm.	21.219
Grams/sec.	mm.	1273.1

Viscous Flow

The basic equation for friction losses due to viscous flow in a circular conduit is the Poiseuille equation

$$\Delta P = \frac{32\mu LV}{gD^2} \qquad (3)$$

where P is pressure drop resulting from pipe friction, lb./ft.^{2}; μ is fluid viscosity, lb./sec.ft.; L is pipe length, ft.; g is the gravitational constant, ft./sec.^{2}; V is average fluid velocity, ft./sec.; and D is pipe diameter, ft. In this form two factors are omitted, enlargement and contraction effects, and hydrostatic heads for other than horizontal flow. Steady continuous flow is assumed.

Tables II*a* and II*b* give value of K for additional inconsistent dimensional quantities. Table II*a* gives the values in volumetric units for the equation:

$$\Delta P = K\frac{\mu LQ}{D^4} \qquad (4)$$

and Table II*b* gives values of K for flow in weight units for the equation:

$$\Delta P = K\frac{\mu LW}{\rho D^4} \qquad (5)$$

Turbulent Flow

In Genereaux's equation (*Chem. Met. Eng.*, 44, 241-8, 1937) for turbulent flow in a commercial pipe:

$$\Delta P = 0.1325 \times \frac{L\,\mu^{0.16}\,W^{1.84}}{\rho D^{4.84}} \qquad (6)$$

ΔP is pressure drop, psi.; L is pipe length, ft.; μ is fluid viscosity, lb./sec.ft.; W is flow rate, thousand lb./hr.; ρ is fluid density, lb./cu.ft.; D is pipe diameter, in.; and K is the numerical value, 0.1325. Table III presents other values for the constant K that allow different combinations of units to be employed.

No attempt is here proposed to justify this simplified equation for fluid flow, instead of using more accurate methods that make allowances for surface roughness and other effects. The latter methods, however, may require more knowledge about the actual flow conditions than is available. In any event there is a need for easier fluid flow calculations that are accurate to perhaps 10%.

For turbulent flow calculations involving fractional exponents, a log-log slide rule should be used to take full advantage of the method. Without a log-log slide rule, conventional methods or alignment charts may be easier to use.

Orifice Calculations

For orifice calculations the usual equation is:

$$V = C\sqrt{\frac{2\,gh}{1-\beta^4}} \qquad (7)$$

where V is average fluid velocity through orifice, fps.; C is the usual orifice coefficient, dimensionless (0.61 for flange connections); g is the acceleration of gravity, ft./sec.^{2}; h is pressure drop, ft. of fluid; and β is the ratio of orifice diameter to pipe diameter.

As used in practice Eq. (7) becomes dimensional. In volumetric units it is:

$$Q = KCd^2\sqrt{\frac{\Delta P}{\rho(1-\beta^4)}} \qquad (8)$$

and in weight units:

$$W = KCd^2\sqrt{\frac{\rho\,\Delta P}{(1-\beta^4)}} \qquad (9)$$

Here d is orifice diameter, in.; and ΔP is the pressure drop, in. of water. K serves in each case to absorb a number of factors, such as g and the change in the units of pressure. Sometimes K is also allowed to absorb the orifice coefficient C. This practice is not followed here and C is kept as originally defined—to express the effect of friction. By retaining C, it is possible to consult the literature for values of C to be used for specific conditions.

Eqs. (8) and (9) can be further simplified by remembering that β is defined as the ratio of the orifice diameter d, divided by the pipe diameter D. Then d^2 can be replaced by its equivalent β^2D^2. Eq. (8) can then be written as:

$$Q = KC\beta^2D^2\sqrt{\frac{\Delta P}{\rho\,(1-\beta^4)}}$$

$$= KCD^2\sqrt{\frac{\Delta P}{\rho}} \times \frac{\beta^2}{\sqrt{1-\beta^4}}$$

$$= KCD^2\sqrt{\frac{\Delta P}{\rho}} \times f(\beta) \qquad (10)$$

and Eq. (9) simplified to:

$$W = KCD^2 \sqrt{\rho \Delta P} \times f(\beta) \qquad (11)$$

Eqs. (10) and (11) are more convenient to use than (8) and (9) only in conjunction with tabulated values for $f(\beta)$. These factors are presented as Table V. The equations will normally be used to calculate flow where the orifice size is known (Case 1) and to calculate an orifice size for given flow conditions (Case 2). The magnitude of the coefficient C depends on whether flange taps, pipe taps or a venturi meter are used. For a given installation the appropriate value of C must be selected. The equations are general and cover all cases.

Case 1—Unknown Flow—When the orifice diameter is known, either Eqs. (8) and (9) or (10) and (11) can be used with no particular advantage either way. In either case it is simply a matter of substituting in the known values and solving for the remaining unknown. Tables IV*a* and IV*b* will be useful in allowing the substitutions to be made in the dimensions in which the data are available without the necessity of changing units. The accuracy of the calculation will depend entirely on the accuracy with which C is known, either from the literature or from calibration. Frequently the value of C is assumed to be 0.61 and is adequate for at least the first approximation.

Case 2—Unknown Orifice Size—Here Eqs. (10) and (11) offer a distinct advantage over Eqs. (8) and (9) as they avoid the usual trial-and-error solutions. Substituting the known data in the equations, a direct solution is obtained for $f(\beta)$. The desired orifice is calculated as the product βD after finding the value of β from Table V.

The shortcoming of this direct method in calculating the orifice sizes is that C varies with β. Thus it is not always possible to select C in advance. It may be necessary to solve for β a second time, using a revised estimate of C based on the value of β first calculated. For many orifice calculations, however, a value of 0.61 for C is sufficiently close. In these instances the method suggested will save time. Even if a second, direct solution is required to obtain the desired degree of accuracy, the method has the advantage of allowing a considerable range of mixed units to be used without the necessity of changing to consistent dimensions.

For the calculation of pipe or orifice pressure drops by the methods presented, no correction is applied for expansion of gases or compressible fluids. Thus, the method is limited to non-compressible liquids or gases where the pressure drop in only a few percent of the absolute pressure.

It is not convenient and probably unnecessary to provide for changes in units of all the variables. Thus, viscosity is always given in centipoises, and pipe length in feet. In the tables for orifice calculations the diameter is given for inches only and not for

Viscous Flow
K . . . Values for Volumetric Flow—II a

Equation: $\Delta P = K\mu LQ/D^4$

Dimensions: Pressure drop ΔP = psi., length L = ft., absolute viscosity μ = centipoises.

Example: $\Delta P = 2.0422 \times 10^{-3} \dfrac{\text{(centipoises) (ft.) (cu.ft./min.)}}{\text{(in.}^4\text{)}}$

Q	K (When D is expressed in units of) Inches	Centimeters
Gpm.	2.7301×10^{-4}	1.1363×10^{-2}
Cu.ft./hr.	3.4037×10^{-5}	1.4168×10^{-3}
Cu.ft./min.	2.0422×10^{-3}	8.5005×10^{-2}
Cu.ft./sec.	0.12253	5.1003
Cc./min.	7.2120×10^{-8}	3.0019×10^{-6}
Cc./sec.	4.3273×10^{-6}	1.8011×10^{-4}

Viscous Flow *K*—Values for Weight Flow—II b

Equation: $\Delta P = K\mu LW/\rho D^4$

Dimensions: Pressure drop ΔP = psi., length L = ft., absolute viscosity μ = centipoises

Example: $\Delta P = 2.0423 \times 10^{-5} \dfrac{\text{(centipoises)(ft.)(lb./min.)}}{\text{(lb./cu. ft.)(in.}^4\text{)}}$

W	D	K (When ρ is expressed in units of) Lb./cu. ft	Lb./gal.	Grams/ml.	Specific Gravity 20/20 C Water = 1.0	Air = 1.0
Lb./hr.	in.	3.4037×10^{-5}	4.5502×10^{-6}	5.4522×10^{-7}	5.4682×10^{-7}	4.6036×10^{-4}
	cm.	1.4168×10^{-3}	1.8940×10^{-4}	2.2696×10^{-5}	2.2762×10^{-5}	1.9163×10^{-2}
Lb./min.	in.	2.0423×10^{-5}	2.7302×10^{-6}	3.2715×10^{-7}	3.2811×10^{-7}	2.7623×10^{-4}
	cm.	8.5005×10^{-2}	1.1363×10^{-2}	1.3617×10^{-3}	1.3657×10^{-3}	1.1494
Lb./sec.	in.	0.12253	1.6380×10^{-2}	1.9628×10^{-3}	1.9685×10^{-3}	1.6573
	cm.	5.1003	0.68181	8.1701×10^{-2}	8.1940×10^{-2}	68.987
Grams/min.	in.	5.4024×10^{-5}	6.0190×10^{-6}	7.2123×10^{-7}	7.2335×10^{-7}	6.0897×10^{-4}
	cm.	1.8740×10^{-3}	2.5052×10^{-4}	3.0019×10^{-5}	3.0106×10^{-5}	2.5345×10^{-2}
Grams/sec.	in.	2.7014×10^{-4}	3.6112×10^{-5}	4.3273×10^{-6}	4.3400×10^{-6}	3.6548×10^{-3}
	cm.	1.1244×10^{-2}	1.5031×10^{-3}	1.8012×10^{-4}	1.8068×10^{-4}	0.15208

Turbulent Flow *K*-Values for Weight Flow—III

Equation: $\Delta P = K L \mu^{0.16} W^{1.84} / \rho D^{4.84}$
Dimensions: Pressure drop ΔP = psi., length L = ft., absolute viscosity μ = centipoises

Example: $\Delta P = 7.4991 \times 10^{-4} \dfrac{(\text{ft.})(\text{centipoises})^{0.16}(\text{lb./min.})^{1.84}}{(\text{lb./cu. ft.})(\text{in.})^{4.84}}$

W	*D*	*K* (When ρ is expressed in units of)				
					Specific Gravity, 20/20 C.	
		Lb./cu. ft.	Lb./gal.	Grams/ml.	Water = 1.0	Air = 1.0
1,000 Lb./hr.	in.	0.1325	1.1713×10^{-2}	2.1225×10^{-3}	2.1287×10^{-3}	1.7920
	cm.	12.068	1.6133	0.19331	0.19388	163.22
Lb./hr.	in.	4.0014×10^{-7}	5.3491×10^{-8}	6.4097×10^{-9}	6.4285×10^{-9}	54.119×10^{-7}
	cm	3.6444×10^{-5}	4.8719×10^{-6}	5.8378×10^{-7}	5.8550×10^{-7}	49.291×10^{-5}
Lb./min.	in.	$\boxed{7.4991 \times 10^{-4}}$	1.0025×10^{-4}	1.20125×10^{-5}	1.2047×10^{-5}	10.142×10^{-3}
	cm.	6.8301×10^{-2}	9.1305×10^{-3}	1.0940×10^{-3}	1.0973×10^{-3}	0.92378
Lb./sec.	in.	1.3670	0.18274	2.1897×10^{-2}	$2\ 1961 \times 10^{-2}$	18.48894
	cm.	124.51	16.645	1.99448	2.00035	1684.0226
Grams/hr.	in.	5.1755×10^{-12}	6.9186×10^{-13}	8.2904×10^{-14}	8.3148×10^{-14}	6.9999×10^{-11}
	cm.	4.7138×10^{-10}	6.3014×10^{-11}	7.5508×10^{-12}	7.5730×10^{-12}	6.3755×10^{-9}
Grams/min.	in.	9.6774×10^{-9}	1.2937×10^{-9}	15.501×10^{-11}	15.547×10^{-11}	1.3088×10^{-7}
	cm.	8.8141×10^{-7}	1.1783×10^{-7}	14.119×10^{-9}	14.1605×10^{-9}	1.1921×10^{-5}
Grams/sec.	in.	1.8094×10^{-5}	2.4188×10^{-6}	2.894×10^{-7}	2.9069×10^{-7}	24.472×10^{-5}
	cm.	1.6480×10^{-3}	2.2031×10^{-4}	2.6398×10^{-5}	2.6476×10^{-5}	22.289×10^{-3}

metric units. These tables could be expanded to cover other units and equations. The increased bulk, however, would be more inconvenient to handle than the occasional problem involving dimensions outside of the scope covered here.

The constants given have been calculated to at least five significant figures in every case. Thus, the use of the proposed Eqs. (2), (4), (5), (10) and (11) will introduce an error of less than 0.01% compared to the alternate solution of the original basic Eqs. (1), (3) and (7) in dimensionally consistent units. If pressure drop for viscous flow in a round pipe is measured by solution viscosity, then Eqs. (3), (4) and (5) are exact; otherwise the viscosity data will limit the accuracy. Genereaux's equation Eq. (6) for turbulent flow is empirical and is a correlation of many experimental results—good to perhaps plus or minus 10%. The accuracy of the orifice coefficient C determines the accuracy of the results calculated by Eqs. (7), (10) and (11).

How to Use the Tables

Problem 1—How many grams/min. of an oil, of viscosity = 7.6 cp. and density = 0.92 grams/ml., will flow through a 1.4 mm. capillary tube when the pressure drop is 1 psi. per foot of tube?

Solution—Here we assume viscous flow and use Table II *b*. The appropriate equation is $\Delta P = K \mu L W / \rho D^4$. From the conditions of the problem, $\Delta P = 1$ psi., $\mu = 7.6$ cp., $L = 1$ ft. $\rho = 0.92$ grams/ml., $D = 1.40$ mm. $= 0.14$ cm., and W, in grams/min., is to be found. Referring to Table II *b*, $K = 1.16651 \times 10^{-2}$. Therefore:

$$1 = 1.166 \times 10^{-2} \frac{7.6 \times 1 \times W}{0.92 \times 0.14^4}$$

and

$$W = \frac{0.92 \times 3.85 \times 10^{-4}}{1.166 \times 10^{-2} \times 7.6} = \text{0.00400 grams/min.}$$

We should now check N_{Re} for flow conditions. By Table I*b*, $N_{Re} = K\, W/\mu\, D$. From the problem W = 0.004 grams/min., $\mu = 7.6$ cp., and $D = 1.4$ mm. For these conditions the table shows $K = 21.219$, so —$N_{Re} = 21.22 \times 0.004/(7.6 \times 1.4) = 0.008$, and the flow is viscous as assumed.

Orifice Ratio: $f(\beta)$ Values—IV

Equation: $f(\beta) = \beta^2/\sqrt{1-\beta^4}$
Example: If $\beta = 0.57$, then $f(\beta) = 0.34354$

β	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.00	0.00000	0.00010	0.00040	0.00090	0.00160	0.00250	0.00360	0.00490	0.00640	0.00810
0.10	0.01000	0.01210	0.01440	0.01690	0.01960	0.02250	0.02561	0.02891	0.03241	0.03612
0.20	0.04003	0.04414	0.04845	0.05297	0.05769	0.06262	0.06775	0.07309	0.07864	0.08440
0.30	0.09036	0.09655	0.10294	0.10955	0.11638	0.12343	0.13070	0.13820	0.14593	0.15389
0.40	0.16209	0.17053	0.17921	0.18815	0.19733	0.20678	0.21650	0.22649	0.23677	0.24734
0.50	0.25820	0.26937	0.28086	0.29268	0.30485	0.31736	0.33026	$\boxed{0.34354}$	0.35722	0.37132
0.60	0.38587	0.40088	0.41639	0.43242	0.44899	0.46615	0.48392	0.50236	0.52150	0.54139
0.70	0.56211	0.58369	0.60622	0.62977	0.65444	0.68033	0.70756	0.73627	0.76660	0.79875
0.80	0.83293	0.86937	0.90842	0.95039	0.99575	1.04502	1.09888	1.15815	1.22398	1.29769
0.90	1.381	1.477	1.589	1.723	1.887	2.095	2.374	2.788	3.447	4.938

Problem 2—What size pipe is required to handle 5,000 lb./hr. of concentrated sulfuric acid at a pressure drop of 2 psi. per 100 ft.? From tables on sulfuric acid we find that $\rho = 115$ lb./cu. ft., and $\mu = 20$ cp. We shall assume turbulent flow and use Eq. (6) and Table III. Here:

$$\Delta P = K \frac{L\, \mu^{0.16}\, W^{1.84}}{\rho\, D^{4.84}}$$

From the conditions of the problem $\Delta P = 2$ psi., $L = 100$ ft. and $W = 5{,}000$ lb./hr. Therefore, from Table III, $K = 0.1325$, so:

$$D^{4.84} = \frac{0.1325 \times 100 \times 1.615 \times 19.4}{2 \times 115}$$

$$D^{4.84} = 1.808$$

Therefore, the pipe diameter D is 1.113 in.

We should now check N_{Re} for flow conditions. From Table I*b*, $N_{Re} = KW/\mu D$. From the problem $W = 5{,}000$ lb./hr., $\mu = 20$ cp. and $D = 1.11$ in. For these conditions the table shows $K = 6{,}315.3$, so $N_{Re} = 6{,}315 \times 5/20 \times 1.11 = 1{,}426$, and the flow is viscous. It is now necessary to repeat the pipe size calculation for viscous flow. From Table II *b*, $\Delta P = K\mu LW/\rho D^4$. From the conditions of the problem $\Delta P = 2$ psi., $\mu = 20$ cp., $L = 100$ ft., $W = 5{,}000$ lb./hr. and $\rho = 115$ lb./cu.ft. For these conditions the table shows $K = 3.404 \times 10^{-5}$. Rearranging the equation gives:

$$D^4 = \frac{3.404 \times 10^{-5} \times 20 \times 100 \times 5{,}000}{2 \times 115}$$

The pipe diameter D for viscous flow equals 1.10 in.

Problem 3—Using an orifice coefficient of 0.61, what pressure drop will result from a flow of 20 gpm. of solution (sp. gr. = 1.137) through a ½ in. orifice plate in a 1-in. Schedule 40 pipe?

Solution—Using Table V *a*, we find:

$$Q = KCD^2 \sqrt{\Delta P/\rho} \times f(\beta)$$

From the conditions of the problem: $Q = 20$ gpm., $C = 0.61$, $D = 1.315$ in., $\rho = 1.137$ and $\beta = 0.50/1.315 = 0.380$. Table IV gives the value of $f(\beta) = 0.14593$ and Table V *a* gives $K = 5.6704$.

Therefore:

$$20 = 5.67 \times 0.61 \times (1.315)^2 \sqrt{\frac{\Delta P}{1.137}} \times 0.1459$$

Hence, the pressure drop, $\Delta P = 597$ in. of water.

Orifice Flow: *K*-Values for Volumetric Flow—V a

Equation: $Q = KCD^2 \sqrt{\Delta P/\rho} \times f(\beta)$

Dimensions: Pressure drop ΔP = in. of water, pipe diameter D = in., orifice coefficient C, $f(\beta)$ see Table IV

Example: Q gpm. = 44.722 (orifice coefficient)(in.^{2}) $\sqrt{\text{in. water/(lb./cu. ft.)}} \times f(\beta)$

	K (When ρ is expressed in Units of)				
				Specific Gravity 20/20 C.	
Q	Lb./cu. ft.	Lb./gal.	Grams/ml.	Water = 1.0	Air = 1.0
Gal./day	64,401	23,547	8,151.1	8,165.3	236,840
Gal./min.	44.722	16.351	5.6605	5.6704	164.48
Cu. ft./hr.	358.71	131.15	45.402	45.481	1319.2
Cu. ft./min.	5.9785	2.1859	0.75670	0.75802	21.987
Cu. ft./sec.	0.099642	0.036431	0.012612	0.012634	0.36645
Cc./min.	169,290	61,895	21,427	21,464	622,590

Orifice Flow *K*-Values for Weight Flow—V b

Equation: $W = KCD^2 \sqrt{\rho \Delta P} \times f(\beta)$

Dimensions: Pressure drop ΔP = in. of water, pipe diameter D = in., orifice coefficient C, $f(\beta)$ see Table IV

Example: W lb./min. = 5.9785 (orifice coefficient)(in.^{2}) $\sqrt{\text{lb./cu. ft.} \times \text{in.water}} \times f(\beta)$

	K (When ρ is expressed in Units of)				
				Specific Gravity 20/20 C.	
W	Lb./cu. ft.	Lb./gal.	Grams/ml.	Water = 1.0	Air = 1.0
1,000 lb./hr.	0.35871	0.98108	2.8342	2.8301	0.097537
Lb./min.	5.9785	16.351	47.236	47.169	1.6256
Lb./sec.	0.099642	0.27252	0.78727	0.78614	0.027094
Grams/min.	2,711.8	7,416.7	21,426	21,395	737.37

Problem 4—What orifice size will be required to produce 100 in. of water pressure drop for a steam flow of 1,000 lb./hr. at 120 psia. in a 1-in. pipe?

Solution—Since flow is in weight units, Table V *b* applies. $W = KCD^2\sqrt{\rho\Delta P} \times f(\beta)$. For the conditions given $W = 1{,}000$ lb./hr., $D = 1{,}315$ in., $C = 0.61$ (assumed), and $\Delta P = 100$ in. water. From the steam tables, we get $\rho = 0.2683$ lb./cu.ft. and from Table V *b* $K = 0.35871$.

Therefore:

$$1 = 0.3587 \times (1.315)^2 \times 0.61 \times \sqrt{0.2683 \times 100} \times f(\beta)$$

Solving the above equation gives $f(\beta) = 0.509$. Interpolating in Table IV gives $\beta = 0.6735$. Hence, $d = 0.6735 \times 1.315 = 0.886$ in.

Problem 5—What size orifice is required in a ½-in. pipe to meter 20 lb./hr. of chlorine vapor at 20 psig. and 30 C. at a pressure drop of 100 in. of water?

Solution—Specific gravity of chlorine vapor relative to air at 20 C. and 1 atm. is:

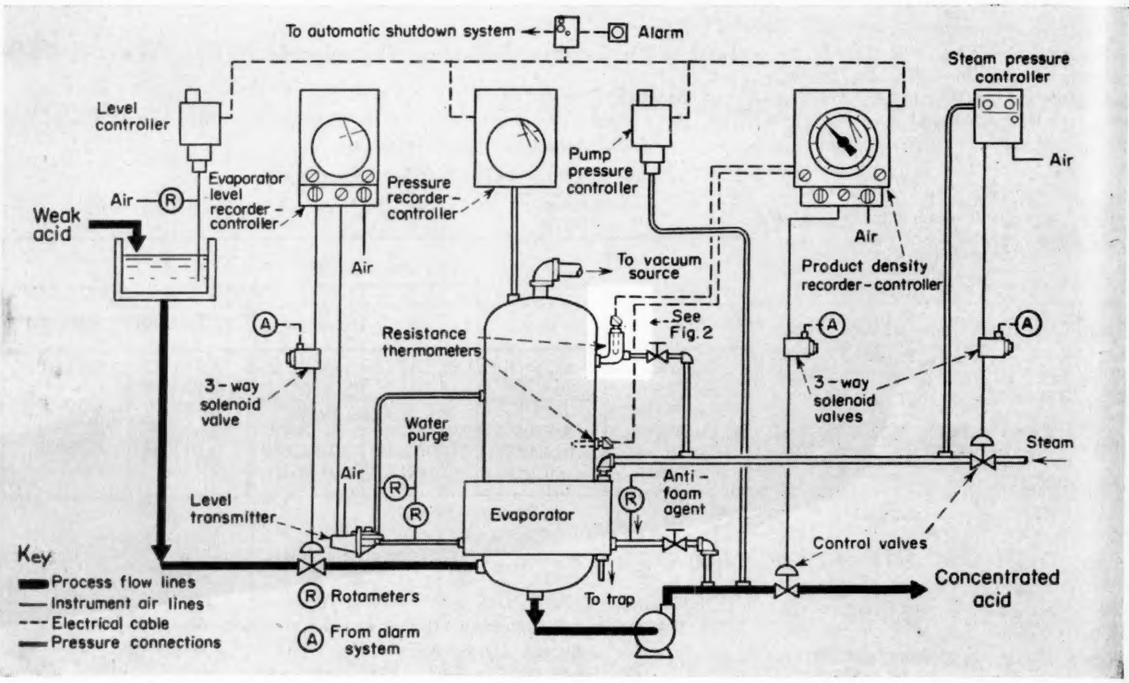
$$\frac{\text{Mol. wt. } Cl_2}{\text{Mol. wt. air}} = \frac{71}{29} \times \frac{20 \times 14.7}{14.7} \times \frac{293\ K.}{303\ K.} = 5.59.$$

For flow in weight units, the orifice size is computed using Table V *b*. Here, $W = KCD^2\sqrt{\rho\Delta P} \times f(\beta)$. For the conditions given $D = 0.623$ in., $C = 0.61$ (assumed), $\Delta P = 100$ in. of water and $W = 20$ lb./hr. The value of $\rho = 5.59$ as previously calculated, and the value of $K = 97.537$ from Table V *b*.

Therefore:

$$20 = 97.54 \times (0.623)^2 \times 0.61 \times \sqrt{5.59 \times 100} \times f(\beta)$$

Solving the above equation, we find that $f(\beta) = 0.0366$. Interpolation in Table IV give $\beta = 0.1913$. Since $\beta = d/D$, therefore the orifice size $d = 0.119$ in.



OLD EVAPORATOR was revamped with new control system, with automatic control of four variables. (Fig. 1.)

Output Up With Revamped Control

Use of boiling-point rise to measure the product concentration enabled batch evaporator to run continuous, with many operating improvements.

GEORGE WEBER, Plant Manager, Stauffer Chemical Co., Brooklyn, N. Y.*

A dramatic example of what can sometimes be accomplished with revamped automatic control occurred about two years ago when our Brooklyn plant undertook to improve an old single-effect, horizontal-tube evaporator. The evaporator concentrates tartaric acid as the first step in the purification process. It had been operated batchwise for many years and had required the full-time services of a skilled operator. The concentration step had become a very expensive one.

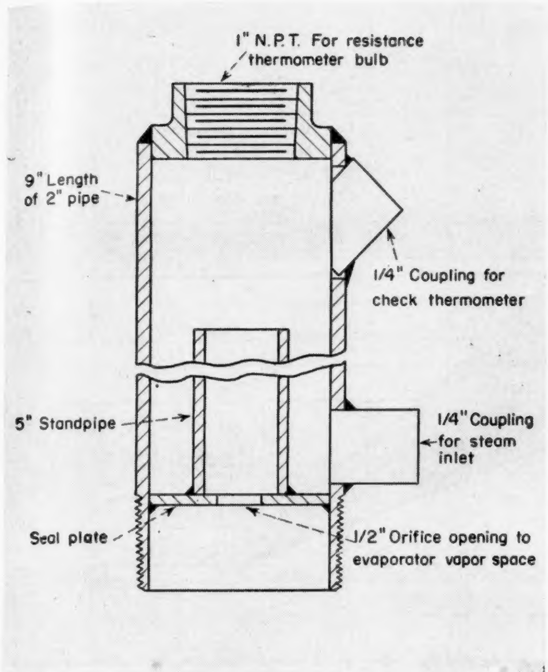
After surveying the economics of the old operation we concluded that production would have to be increased by making the evaporator continuous, and this would require full automatic control. For any evaporator of this sort, the basic control instrument is a continuous concentration controller. In concentrating tartaric acid, impurities tend to crystallize out and these crystals would clog the lead lines and make trouble with bubble-tube or displacement-type density measuring instruments. So the decision was to accept the suggestion of the instrument supplier's engineers and use a boiling-point-rise controller, together with a new reference chamber recently developed by the supplier's application engineers.

The boiling-point-rise method is not new; it has long been known that there is a usable relation between product concentration and boiling-point rise. The instrument used is electronic, employing two differentially connected resistance-thermometer bulbs, one to measure the temperature of the boiling liquid in the evaporator, the other to measure the temperature of saturated steam at the evaporator pressure. The instrument then measures the difference between the reference (saturated steam) temperature and the boiling liquor temperature, and this difference is a measure of product concentration.

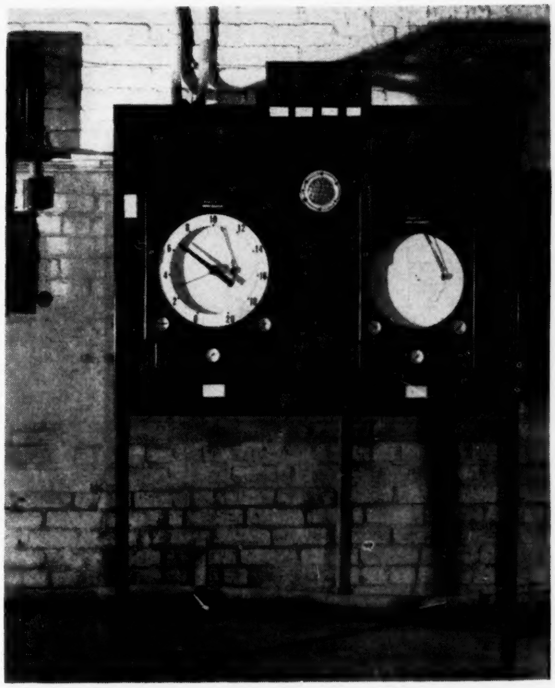
Although the boiling-point-rise method is simple in theory, its use has been held back because of difficulties in securing a satisfactory reference temperature, and sometimes because of neglect to control two other variables, evaporator pressure and liquid level, both of which require accurate control if the boiling-point-rise method is to work properly.

Most boiling-point-rise installations use a barometric leg to establish an accurate reference temperature. This is satisfactory except for high expense—since it must be about 35 ft. tall. Also, with single-effect evaporators, this height is

* Meet your author on p. 322.



REFERENCE CHAMBER is easily constructed. (Fig. 2.)



CONTROL PANEL shows simple installation. (Fig. 3.)

often impractical since the evaporator itself may be 10 to 20 ft. shorter. Minneapolis-Honeywell application engineers solved this problem neatly with a simple 9-in. reference chamber which can be purchased or can easily be constructed in any plant shop (Fig. 2). The bottom of the chamber is attached to a port connected to the evaporator vapor space. A small flow of 5- to 20-psig. steam is supplied to the steam inlet of the chamber, with just enough flow to cause steam condensation in the chamber.

Steam entering the chamber expands to evaporator pressure (usually about 3 in. Hg abs.), thus becoming superheated. But since the chamber is air cooled, the steam then condenses at the temperature of saturated steam at evaporator pressure, thus producing the correct reference temperature.

The actual instrumentation used in the revamped control system is diagrammed in Fig. 1. Four variables are automatically controlled, including (1) level of acid in the evaporator, (2) pressure in the evaporator, (3) pressure of steam to the steam chest, and (4) outflow of acid of proper concentration. In addition to the controlled variables, four factors are tied into an automatic alarm and shutdown system, including: (1) level in the weak-acid supply tank, (2) evaporator pressure, (3) product-pump discharge pressure, and (4) acid concentration. If any of these factors should get out of control, the system will sound an alarm and automatically shut down the acid feed and discharge, and the steam supply. This is accomplished by using small three-way solenoid valves to bleed the air from the three diaphragm control valves, thus allowing them to close.

Pressure control in the evaporator is one of the most critical factors since pressure changes of say 1 in. Hg can easily result from variations in water and steam supplied to the condensers and ejectors. This is enough to affect the boiling-point-rise measurement seriously. An old self-operating pressure-control unit mounted on the evaporator bleeds air into the body for pressure control. This is monitored by a new pressure recorder-comptroller which ties into the alarm system.

Liquid-level control is somewhat less critical and the small inevitable level fluctuations due to boiling are not harmful. However, level control is necessary to eliminate temperature-measurement errors due to varying hydrostatic head. Level is measured by differential pressure above and below the liquid level in the evaporator, with water-purging of both lines to prevent clogging by crystal impurities. The associated pneumatic controller adjusts the feed of incoming weak acid to hold the level within close limits.

As Fig. 1 indicates the boiling-point-rise controller operates to maintain a fixed temperature difference (constant output concentration), by controlling the product discharge with a pneumatic valve in the product outlet line.

The new system shows many advantages over the old. By going continuous and eliminating delay between batches, output has been increased by 10%. Eliminating a full-time operator has cut operating costs by 90%—attention being needed only at startup. Uniformity of operating conditions has decreased scaling and improved steam economy, with a 25% reduction in maintenance costs. Finally, the control system is not only trouble-free, but it has improved product quality by consistently holding the concentration with ¼ of 1%.

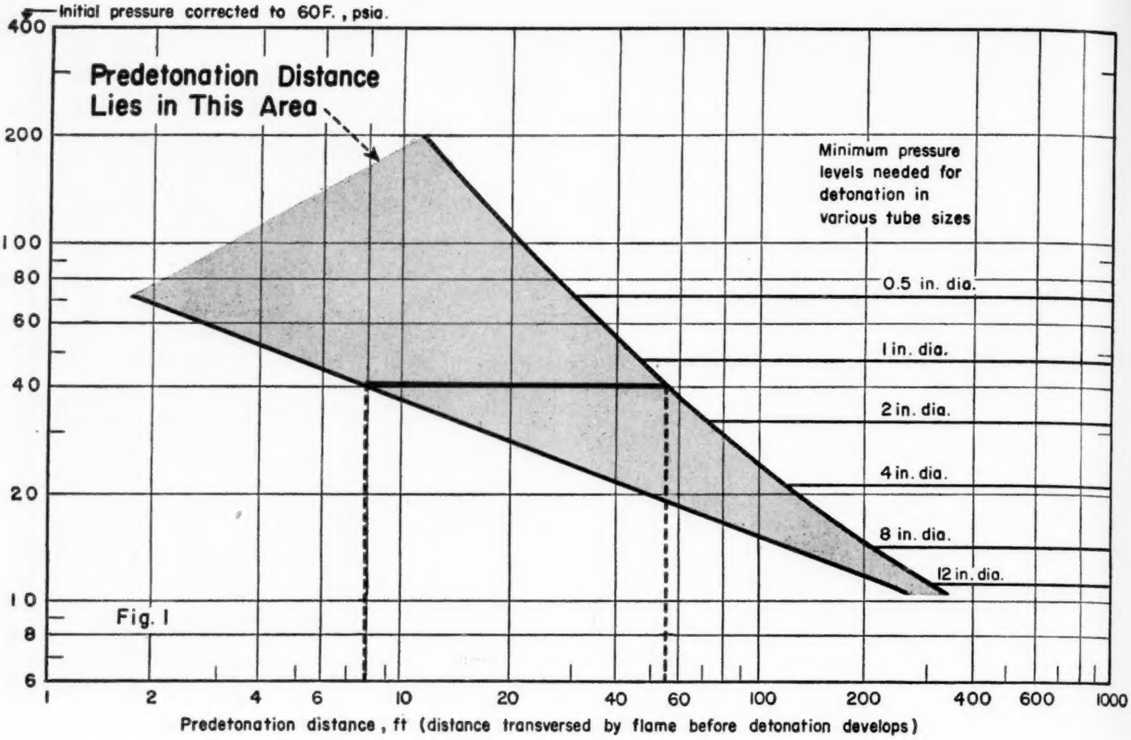


Fig. 1

How to Design a Hazard-Free System

Once you establish the predetonation distance for your acetylene system you can predict how much force an explosion will produce. That gives a firm design basis to overcome hazard.

H. B. SARGENT, Linde Air Products Co., New York 17, N. Y.

When acetylene ignites, its behavior during decomposition may vary widely. Heat is evolved and, if conditions are right, decomposition can spread throughout an extensive system.

Occasionally, pressure rises hardly at all. More frequently, the pressure reaches a level tens or hundreds of times greater than the initial pressure.

The reasons why acetylene sometimes behaves so differently are sufficiently obscure to tempt us to call acetylene fickle. However, we have data that indicate behavior of a decomposition wave in acetylene is very sensitive to the kind of ignition and to small changes in the initial conditions, particularly gas pressure and vessel dimensions and proportions.

With these data, we can predict the course of events following thermal ignition of commercial acetylene gas in tubular vessels, at room temperature and over a range of pressures. These predictions can guide our application of the following three methods for treating the decomposition hazard of compressed acetylene:

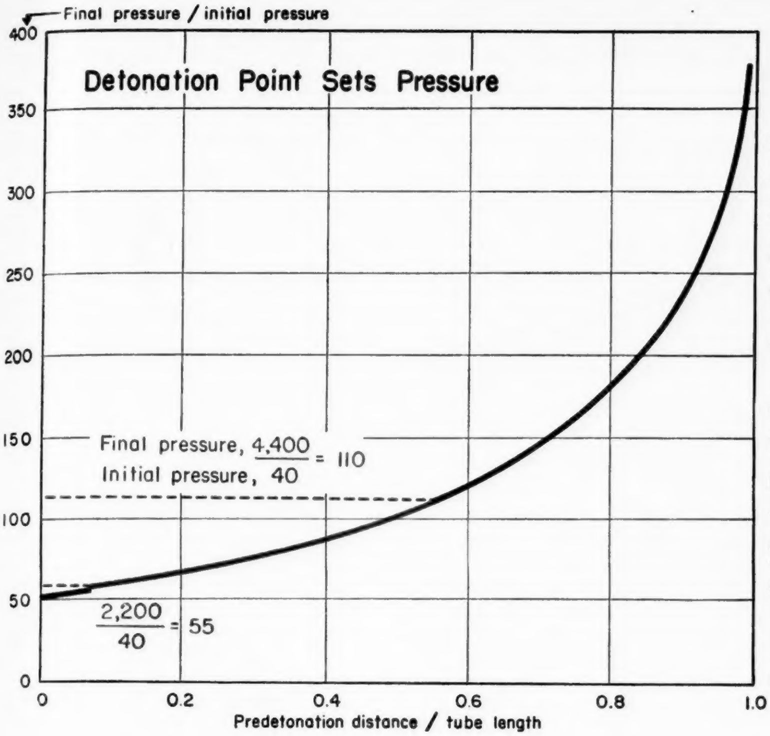
- Make it impossible for a flame to propagate throughout the system.
- Release gas from the system during the decomposition to lower the final pressure.
- Make the equipment strong enough to withstand the pressure resulting from an explosion.

How Explosion Develops

Acetylene explodes either by deflagration (a relatively slow decomposition) or by detonation (a very rapid decomposition). Many times, and particularly in long tubes, the explosion is first a deflagration followed by a detonation.

When the burning starts as a deflagration and changes to a detonation after extended travel, surprisingly high pressures can develop. That's why it is important to be able to predict whether a particular set of conditions is likely to lead to this type of behavior.

*Meet your author on page 327.



When ignited above a minimum pressure within a 1½-in. dia. or larger long tube, 40-psia. acetylene will detonate somewhere between 8 and 55 ft. from the point of ignition.

For a 100-ft. tube, this predetonation distance indicates that final pressure from detonation within the long tube will fall in the range between 2,200 and 4,400 psi., a 55- to 110-fold rise.

Fig. 2

to Handle Acetylene

Deflagration—A gas deflagration flame travels into the unburned gas at a rate slower than the speed of sound or small pressure waves in the unburned gas. Rate of propagation increases with density, temperature and turbulence of the unburned acetylene. Since these three parameters tend to increase as an explosion progresses, the rate of propagation usually is not steady but tends to increase continually.

Theoretically, during constant-volume deflagration of acetylene at 1-5 atm. without loss of heat, the pressure rises to 11.5-11.9 times the initial pressure.[12] When acetylene at 1 to 5 atm. explodes, pressures usually have been found to approach this ratio, provided vessel shape and size are such that the explosion does not involve detonation.

In a long, narrow tube, deflagration sometimes does not travel at an ever-increasing rate. Rather, it settles down to a very slow steady rate that seems to depend on the initial gas pressure and temperature.

Minimum acetylene pressure at which a deflagration flame can propagate throughout a long tube of any diameter is shown by the lower curve in Fig. 3. Curve is based on the experimental results of several investigators,[1-6] who used tubes so long in most cases that further length would not have changed the result greatly. When tubes are relatively short compared to width, results tend to correspond to a curve somewhat lower than that shown.

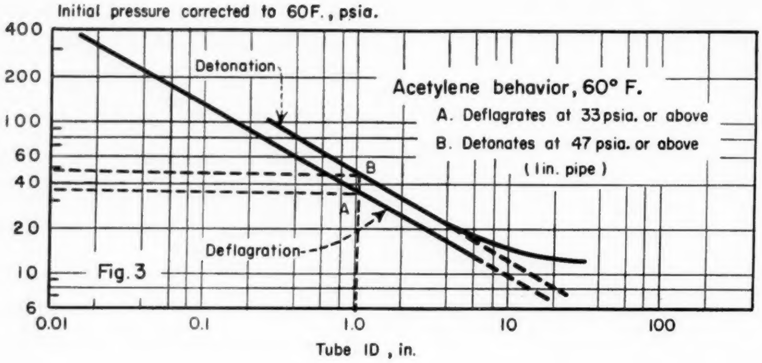
Detonations—In a detonation, the flame travels into the unburned gas at a rate faster than the speed of sound. Usually, the rate is several times greater than the speed of sound, or several thousand feet per sec.

There is a sharp difference in pressure between the unburned and burned gas. This difference takes place in a discontinuous jump (shock wave) at the very head of the flame. Such action is quite unlike a deflagration where the pressures of both unburned and burned gas volumes rise at the same time.

Two concepts of the pressure profile of the leading few millimeters of an ideal detonation wave are illustrated in Fig. 4a, 4b.

In the generally accepted Zeldovich-Von Neumann-Doering[7,8,12] concept, Fig. 3a, the reacting material is at considerably higher pressure than the completely reacted products. However, Cook, Keyes and Filler[9] have presented evidence recently that the pressure is substantially equal throughout the reaction zone, Fig. 4b. A possible exception is for the extremely short distance of several mean-free-path lengths at the extreme front.

Whatever the exact structure, a



constant set of conditions relating to pressure, temperature, density and gas velocity moves through the gas at a steady rate (about 6,600 ft./sec. in acetylene) until it has passed through and decomposed all the gas in the system.

The pressure curve for the burned gas (on the left, Fig. 4) is not actually horizontal but becomes more nearly so as the detonation travel-distance increases. The pressure profile at early and late stages of travel is shown for an ideal detonation wave progressing through acetylene in a closed-end tube, Fig. 5a, 5b.

Compared to Fig. 4, the horizontal scale is compressed greatly and the reaction zone, shown by the broken-line spike, occupies only a small fraction of the total length. In practice, a detonation rarely starts fully formed at one end of a tube, as we have assumed here. Therefore, the pressure profile varies somewhat from this ideal form.

Gas that has just been burned in a detonation wave (Chapman-Jourguet plane, Fig. 4) has about twice the pressure produced by the same gas in an adiabatic constant-volume deflagration, or about 20 times the initial pressure.

If we adhere to the Zeldovich-von Neumann-Doering model, Fig. 4, the pressure of the gas that has just passed through the shock front at the head of the reaction zone is about twice the pressure at the C-J plane, or about 42 times the initial pressure. The amount of gas that has this higher pressure is so small that the shock-front pressure is not important with regard to the strength of industrial equipment.

A much more significant pressure is that at the C-J plane. We shall neglect the reaction zone spike, which is shown dotted in Fig. 5, and assume that the effective pressure of the gas is shown by the solid curves.

This is the same as choosing the model of Cook and associates, Fig. 4b, in preference to that of Zeldovich, von Neumann and Doering, Fig. 4a.

When gas that is moved forward by the detonation wave meets an obstruction such as the end of the tube, its pressure rises and a shock wave is reflected back toward the point of origin. The effect is similar to water hammer.

Pressure built up at the point of reflection is 2.5 times the original detonation pressure at the C-J plane. Note this effect in the pressure profiles of a reflected wave, Fig. 5a and 5b.

Maximum pressure developed by reflection of an ideal detonation wave at the downstream end of the tube is about 40 times the initial acetylene pressure. As the reflected shock wave moves with diminishing strength back toward the ignition end of the tube, pressure at the point of reflection starts to fall immediately. You can see this by comparing Fig. 5b with 5a.

Pressure drops less rapidly in a long tube than in a short one. In a long tube, pressure at the end remains near its maximum long enough so that the destructive effect approaches that resulting from an equal hydrostatic pressure.

In a short tube, however, pressure may fall off so rapidly that the destructive effect is noticeably less. This may be due to the ability of steel to resist a very short-duration load with a strength that is higher than the statically measured yield strength.

Even though pressure in the gas at the closed end of the tube is developed by dynamic forces it is a static pressure. It pushes as hard on the sidewalls adjacent to the end as it does on the end itself.

Cascading—Two-step decomposition by deflagration-detonation (cascading) can produce very high pressures if a large portion of the gas is decomposed during the deflagration phase. You can estimate the magnitude of this pressure from Fig. 2 if you know the ratio of the predetonation distance to the tube length.

For example, suppose that a flame propagates as a deflagration along 8/10 the length of the tube, then becomes a detonation and continues to the end of the tube. From Fig. 2 we can estimate that the shock wave reflected from the end of the tube develops 179 times the initial pressure. Thus, cascading can lead to final explosion pressure ratios much greater than straight deflagration (11.5-fold boost) or straight detonation (50-fold boost).

In calculating the curve of Fig. 2, the deflagration stage was assumed to progress without heat loss, yet slowly enough so that the pressure is equal throughout the system up to the moment of transition of detonation.

Manson's calculations[12] of the detonation properties of compressed, preheated acetylene were used to find the C-J pressure of the compressed gas. Multiplication of this result by 2.5 gives the final reflected pressure.

Experimental evidence indicates that cascading often occurs when acetylene, within commonly used pipe sizes, is ignited. And the pressure ratios produced thereby have the same magnitude as the example above. Rimarski's experiments[2] and more recent work done in our laboratories[1] have indicated several pressure ratios in the 100-165 range. Still later experiments have indicated ratios as high as 230.

Over-driving—Observations show that there is greater evidence of pressure at the point where detonation first develops than farther along the travel path. Many photographs of the transition from deflagration to detonation show the flame making a discontinuous leap

forward at the instant of transition.

The detonation front seems to form in the unburned gas a short distance ahead of the deflagration flame. This new flame travels forward initially at a higher velocity than the normal detonation velocity. But it soon falls to the normal velocity and then continues steadily to the end of the tube.

At the most, excess pressure associated with inception of detonation seems to be of the same order as the pressure at the C-J plane of a stable detonation wave, and also as the increase due to reflection of such a wave from the closed end of the tube.

This effect is small compared to that resulting from cascading. Since cascading also is associated with the transition from deflagration to detonation, the over-driving effect probably always augments cascading to some extent.

When Does It Detonate?

In dealing with detonations, a "long" tube is one that is several times longer than the predetonation distance. The predetonation distance, of course, is the distance the decomposition flame travels from the point of origin to the detonation point.

Upper curve of Fig. 3 attempts to show the minimum acetylene pressure needed for a deflagration to develop into a detonation in a long tube of any diameter.

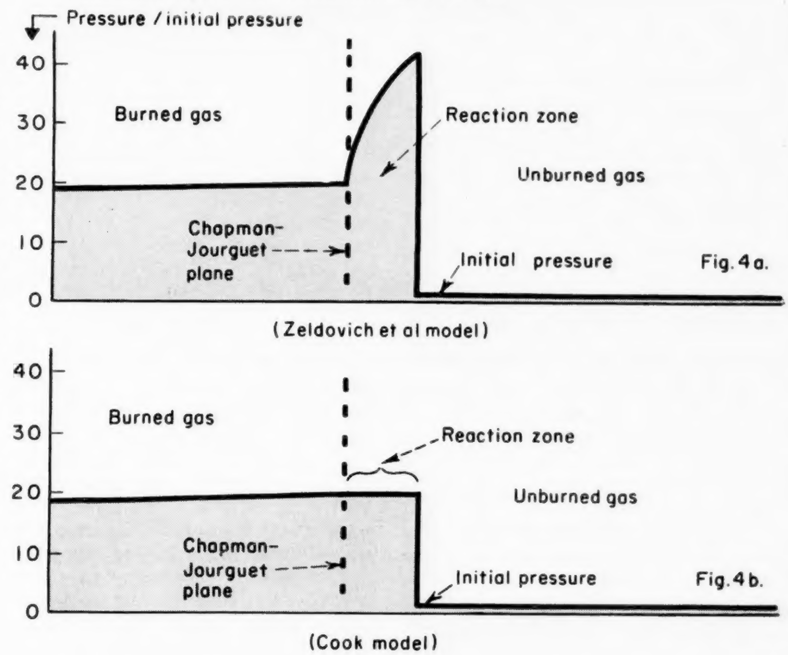
In short tubes, the detonation curve can be coincident with the deflagration (lower) curve. Reason is that a deflagration in a short tube can raise the general pressure level quickly and make a detonation more likely, thereby.

There is evidence that a charge of high explosive can initiate a detonation in acetylene that will continue to propagate even though the pressure may be considerably lower than either of the curves on Fig. 3.

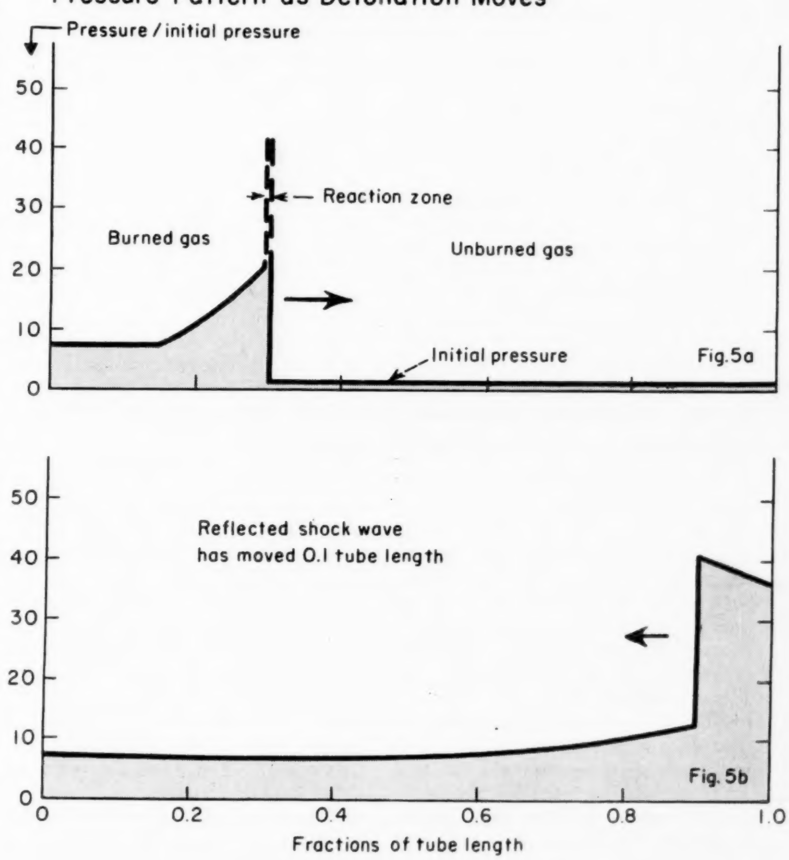
Pressure rise in a long tube is small during the deflagration stage. Should any detonation form, its characteristics are determined rather closely by the initial conditions.

Since the cascading effect is highly sensitive to the relation between predetonation distance and the length of the tube, it is very desireable to predict the predetona-

Two Concepts of Detonation Profile



Pressure Pattern as Detonation Moves



tion distance for any set of conditions. Then we can predict how much pressure to expect on ignition.

From Fig. 1 we can get a general idea of the predetonation distances for acetylene at different pressures. For example, with an acetylene pressure of 40 psia., the predetonation distance lies in the 8-55-ft. range. Of course, we assume here that the tube diameter is large enough to permit detonation at this pressure.

Horizontal lines on Fig. 1 show the minimum pressures required for detonation in tubes with different diameters. We can see that the 8-55-ft. range applies to 1.4-in. dia. tubes and larger.

Data plotted in Fig. 1 applies to detonations that develop in acetylene from deflagrations and thus, ultimately, from non-shock thermal sources. The shock wave from a charge of high explosive fired in the end of a tube of acetylene can cause a detonation to form immediately. Even the explosion of a pocket of oxygen-acetylene mixture in a tube probably can shorten the predetonation distance greatly.

Use Charts for Design

To prevent a deflagrative flame from propagating throughout a system, keep the diameter small or the tube sub-divided below the limit indicated for various pressures by the lower curve, Fig. 3. If the tubes are short or the temperature is above room temperature, the diameter should be considerably less than the curve indicates. And remember that flame from detonative ignition can propagate over considerable distances, if not indefinitely, in smaller-diameter tubes than the curve indicates.

Gas released from the system during decomposition can lower the final pressure. But it must occur during the deflagration stage, in sufficient quantity, and from such a location that it will lower pressure of the unburned gas. Once detonation has started, the flame travels so rapidly that further release is not effective.

Equipment built to withstand an acetylene explosion should be tested with pressure applied slowly to a level slightly higher than the highest explosion pressure that can be expected. Explosion pressure can be estimated, at least in magnitude, from the information we have given. You can see how from the examples that follow.

Example 1—Consider a 4-in. pipeline, 200 ft. long, that carries acetylene at 40 psia. On Fig. 3 we see that this operating pressure is well above the minimum pressure at which both deflagrating and detonating explosions will propagate through a 4-in. pipe.

From Fig. 1 we can predict that thermal ignition near a closed end will produce deflagration that will travel between 8 and 55 ft. before changing to detonation. Since the predetonation distance is a minor fraction of total tube length (0.04 to 0.275), we can see from Fig. 6 that cascading would be minor. Thus, maximum pressure exerted on the closed end of the pipe would be of the order of 50-75 times the initial pressure, or 2,000-3,000 psia.

Example 2—If the 4-in. pipe mentioned above happened to be only slightly longer than the 55-ft. maximum predetonation distance, then cascading would have to be considered an important factor. Assuming a total length of 70 ft., the highest likely ratio of predetonation distance to tube length is a major fraction of total tube length (0.8).

From Fig. 6, the explosion pressure ratio would be of the order of 179, or a final pressure of 7,160 psia.

Predetonation distance might be less than 55 ft. which would make the final pressure less than 7,160 psia. However, we could not be sure of this.

Example 3—A tubular vessel with 4-in. dia. and 5-ft. length could carry acetylene at 40 psia. without danger of explosion pressures rising beyond about 11.8 times the initial pressure, or 472 psia. This can be predicted because vessel length is less than the minimum predetonation distance for 40 psia. shown in Fig. 1. Therefore, only deflagration can occur.

Example 4—If deflagration is once established in a 12-in.-dia. tube carrying 15 psia. acetylene several hundred feet, detonation can be expected, also. Yet very few detonations have been observed because under these conditions self-propagating deflagrations are very difficult to establish.

When a small ball of fire forms in a large volume of acetylene, it may not have sufficient available heat to raise the adjacent layer of cold gas to its ignition point. In other words, the volume of gas in the cold layer is too great for the available heat and the flame will fail.

In a system of this type, propagating deflagrations are established more easily by extended sources of heat. Large flames playing on the exterior surface of the tube might provide such a source.

Once a wall of flame has formed across the tube, the most critical stage in starting an explosion has passed. From here on in, the deflagration may well accelerate and lead ultimately to detonation, perhaps augmented by cascading.

In a case such as this, it may be more practical to prevent ignition or subdivide the tube to smaller effective diameter than to rely on tube strength to withstand pressure that may develop.

Example 5—A low-pressure acetylene gas holder is a tube with diameter comparable to length. From Fig. 1, we can infer that detonation initiated thermally in such a system is highly unlikely.

To the writer's knowledge, no detonation-type decomposition has ever occurred in one of these holders. Theoretically, deflagration is possible if the thermal ignition source is large enough to overcome the difficulties mentioned under Ex. 4.

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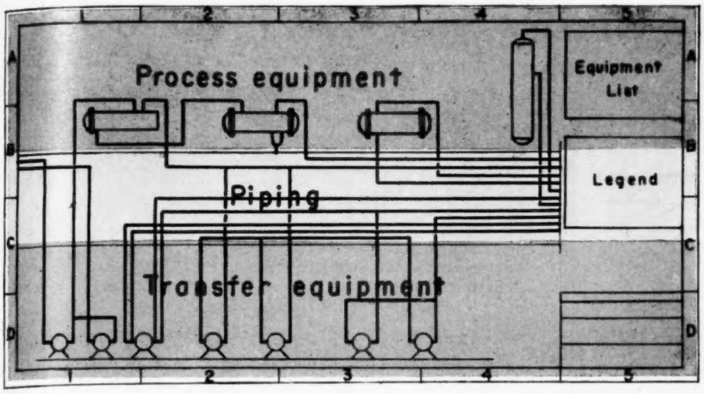


• **Findability: Equipment is indexed like a road map for easy findability.**

• **Tiering: Equipment is arranged in three tiers by type for easy take-off.**

• **Connection: Middle tier, saved for piping, simplifies connection to adjacent pages.**

"Road-Map" Flowsheets for Findability

ANTHONY A. ROMEO, c/o James P. O'Donnell, Cons. Engr., New York*

THE ENGINEERING piping flowsheet is probably the most widely used single reference drawing for any projected process plant. In its principal role, it is vitally important as the piping designer's "bible." But more, it frequently is the key drawing around which top-brass conferences revolve. It is in constant use throughout the engineering office. It is a needed guide in procurement. Finally, it is at the erection superintendent's right hand from start to finish of the job.

As described here, the functional piping flowsheet merges all the good features of different flowsheets I have seen, and some ideas of my own. Its goal is to make it: (1) Fully informative for the piping designer, (2) easy to read no matter who its reader is, nor what his particular interest may be, and (3) easy to locate any item to facilitate discussions whether they be around the drafting board, around the conference table, or by interoffice or long distance phone.

While the diagram reproduced on the next page is an engineering piping flowsheet, certain of its features can be adapted to other types. The flowsheet shown is of no particular process; the piping and equipment were selected simply to show the features of this method. The method has been applied in practice. It was well received.

The flowsheet's makeup is as follows:

A table of equipment serves as an index. It is divided into three columns to show equipment symbols, equipment titles, and letters and numbers which serve as keys to the location of all equipment. In a flowsheet requiring more than one page, the table appears on the lead page only.

A legend section gives separate identities to primary and secondary process lines, service and steam-traced lines, and items such as sewers, manholes and blind flanges, all by means of symbols. Furthermore, different valves serving different purposes are given special symbols to identify their types and operating status, and in like manner sewers are identified as to kinds.

Each separate page of the flowsheet is sectioned off into areas like a road map; the horizontal panels are lettered, and vertical panels are numbered. Thus, by referring to the equipment table, any item can be instantly located; for example, tower T-1 is in area A-4.

In multiple-page flowsheets, single-digit numbers are used in the vertical panels on the first page while two-digit numbers are used in those of all successive pages, for example, 12, 22, 32, etc., on the second page; and 13, 23, 33, etc., for the third page. The last number is used to indicate the page, while the first refers to the vertical panel. Thus, if the key shown in the equipment table reads C-46, the item appears on p. 6 in area C-4.

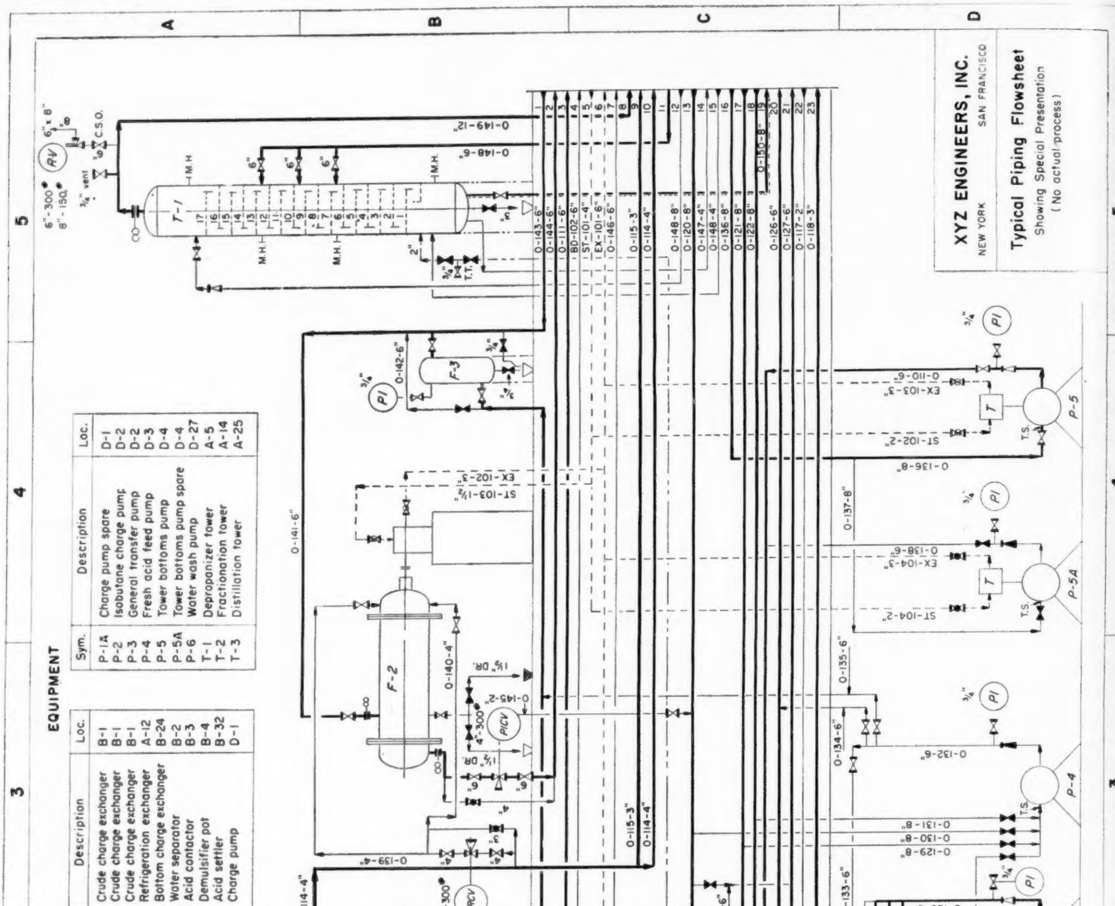
The diagram is divided into three tiers. The top tier shows all process equipment—vessels, exchangers, drums, heaters, and like units—as well as sewer lines drawn to imaginary base lines with their appropriate symbols. All transfer equipment—pumps, compressors and the like—is shown in the bottom tier. The middle tier is the transfer area which is reserved to show whether piping connects units in the top and bottom tiers, or leaves the page. Each space in the transfer area is numbered. Thus, lines leaving one page to be continued on another will match in position from page to page.

It will be noted that primary process lines are drawn heavy while secondary process lines are light. The resulting contrast makes the flowsheet easier to read and the flows can be more readily traced. Service lines are indicated by dashes, and by varying the length of the dashes, the several different kinds of lines can be shown.

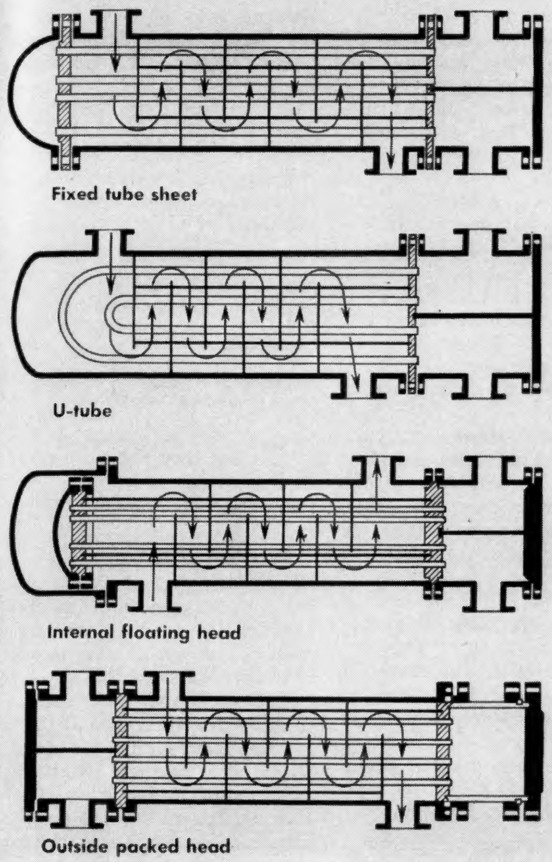
However the flowsheet may be used, its primary function is to guide the piping designer. Consequently, the more fully and clearly it presents its information, the less need he will have to search it out in the job specifications. In particular, the information should include such frequently overlooked items as sizes of all instrument connections to be shown on the piping layout, the location of tower manholes with respect to trays, the sizes of all vent lines and drain connections, and the sizes of control valves and their bypasses, together with flange ratings.

(Turn page for "Road-Map Flowsheet.")

* Meet your author on p. 325.


XYZ ENGINEERS, INC.
NEW YORK SAN FRANCISCO
Typical Piping Flowsheet
Showing Special Presentation
(No actual process)
LEGEND
Steam-traced line
Process line, primary flow
Process line, secondary flow
Steam and exhaust lines
Water line
Gate valve, normally opened
Gate valve, normally closed
Globe valve, normally opened
Globe valve, normally closed
Check valve, normally operating
Check valve, normally not operating
Relief valve
Clean water sewer
Acid sewer
T.S. Temporary strainer
T.T. Tell tale
Instrument
Fig."8" blind flange
T.W. Thermo-well
M.H. Manhole
C.S.O. Car-sealed open
EQUIPMENT
Sym. Description Loc.
E-1A Crude charge exchanger B-1
E-1B Crude charge exchanger B-1
E-1C Crude charge exchanger B-1
E-2 Refrigeration exchanger A-12
E-3 Bottom charge exchanger B-24
F-1 Water separator B-2
F-2 Acid contactor B-3
F-3 Demulsifier pot B-4
F-4 Acid settler B-32
P-1 Charge pump D-1
P-1A Charge pump spare D-1
P-2 Isobutane charge pump D-2
P-3 General transfer pump D-2
P-4 Fresh acid feed pump D-3
P-5 Tower bottoms pump D-4
P-5A Tower bottoms pump spare D-4
P-6 Water wash pump D-27
T-1 Depropanizer tower A-5
T-2 Fractionation tower A-14
T-3 Distillation tower A-25

In designing heat exchangers...



You can reduce trial-and-error time for establishing optimum heat transfer rates and pressure drops.

How to Simplify Shell Side Calculations

Here is a simple, direct method for getting cross-flow clearance and number of tubes crossed by the shell fluid.

FRANK L. RUBIN, Downingtown Iron Works, Downingtown, Pa.*

Heat transfer calculations are of vital importance to many design engineers. But there are two stumbling blocks confronting most engineers working on shell side calculations: determination of the net free area available for cross flow and the number of tubes crossed by the shell side fluid at each baffle space.

We've developed a new, simplified method for such calculations which eliminates the need for tedious trial-and-error attempts.

* Meet your author on page 318.

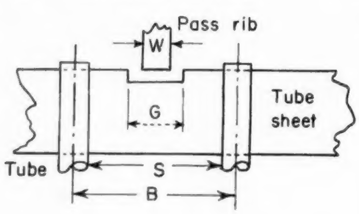
Before discussing the method, let's review some basic design considerations. First, all shell-side heat transfer and fluid flow calculations are dependent on physical properties of the fluid and arrangement of tubes and baffles. Also, baffle spacing is a variable over which the designer has direct control. And cross-flow clearance at the center of the tube nest is fixed by the internal shell diameter, type of construction, tube diameter and tube spacing. This clearance is not directly proportional to shell diameter. For example a fixed tube sheet exchanger with 1 in. tubes arranged on a 1¼-in. triangular pitch for six tube passes has a cross flow clearance of 7 in. for the 25-in., 27-in., 29-in. and 31-in. I.D. exchangers.

Internal shell diameter for moderate pressures generally coincides with the inside diameter of standard pipe (Schedule 40 up to 10-in. I.P.S. and ⅜-in. walls for large diameters). Beyond 24-in. I.P.S. internal diameters are in accordance

Nomenclature Inches

B Minimum spacing between adjacent tube centers = S + o.d.
F.T.S. Fixed tube sheet.
G Groove in tube sheet at pass partition bridge.
I.D. Internal shell diameter.
I.P.S. Iron pipe size.
N No. of tubes at center of shell.
o.d. Outer tube diameter.
O.D. Outer shell diameter.
O.T.C. Outer tube center = O.T.L. − o.d.
O.T.L. Outer tube limit.
S Minimum spacing between adjacent tube rows.
W Thickness of pass partition bridge per TEMA standards Class R and Class C.

How to Find "B" Correction Factor



	Shell Diam. 5–24	Shell Diam. 25–43
W	3/8	1/2
G	1/2	5/8
S	3/4	7/8
B for 5/8" tube	1 3/8	1 1/2
B for 3/4" tube	1 1/2	1 5/8
B for 1" tube	1 3/4	1 7/8

with Tubular Exchanger Manufacturers Assn. (TEMA) standards at 25, 27 and 29 in. etc. Clearances required for the different types of construction set the spacing between the inside of the shell and the outermost tube. Outer tube limit (*O.T.L.*) is thus determined. And the outer tube center (*O.T.C.*) can be calculated.

Table I presents a tabulation of outer tube limits and shell diameters for fixed tube sheet, outside packed head, and internal floating head exchangers. Clearances for the U-tube construction are the same as for the fixed tube sheet design (*see drawings of exchangers*).

In choosing a heat exchanger design, remember:

- Fixed tube sheet construction provides the maximum number of tubes and the minimum cross flow clearance in a given size shell. The outer tube limit is fixed by manufacturer's tolerances between tubes, baffles and shell.
- Outside packed head design provides a straight tube removable bundle at minimum cost. This design is often used in the chemical industry. The outer tube limit is reduced because of the floating head skirt (or barrel).
- The internal floating head heat exchanger with a split backing ring provides the maximum number of tubes in a shell for a straight tube removable bundle (where the shell side fluid is contained without a packed gland). Outer tube limit is reduced because the floating tube sheet, which must be capable of moving through the shell, has a gasket beyond the tube limit.

Calculating Clearance

Cross flow clearance can be approximated by the following method:

$$O.T.C. = O.T.L. - o.d. \quad (1)$$

No. tubes at center* (1,2,4 ribbon arrangement) $= \dfrac{O.T.C.}{\text{pitch}} + 1 \quad (2)$

No. tubes at center* (4 pie or 6 pass) $= \left[\dfrac{O.T.C. - B}{2 \times \text{pitch}} + 1\right] 2 \quad (3)$

Blocked center distance = o.d. × No. tubes at center (4)

Cross flow clearance = shell I.D. − blocked center distance (5)

The factor *B* takes into account tube spacing at the pass rib (*see table*), which becomes important in arrangements with vertical pass ribs. Thickness of the pass bridge is in accordance with TEMA standards Class R and C.

Cross flow clearance at the center of the tube bundle for fixed tube sheet and internal floating head exchangers is listed in Table II. For equilateral triangular pitch the clearance is the same as for the square pitch, when the flow is into the 60° angle of the tube pitch pattern. Clearances for ⅞-in. o.d. tubes on 1 3/16-in. pitch, ¾-in. tubes on 1-in. pitch and 1-in. tubes on 1¼-in. pitch are given.

Clearances are also given for exchangers without any central pass rib (Fig. 1) and with a single central pass rib (Fig. 1). For units with more tube passes the cross flow clearance is further increased. As a first assumption take the values of the central bridge clearance (4 pie or 6) and add one tube diameter.

No. Tubes Crossed

Pressure drop calculations for shell side flow in baffled heat exchangers require a knowledge of the number of tube rows crossed by the fluid at each baffle space. Relatively accurate results can be

* For two or more tube passes the tubes are actually spaced on a chord, not on a diameter of the *O.T.C.* circle. Thus the number of tubes at the center may be less in multi-pass arrangements. Table II allows for this condition.

Outer Tube Limits for Heat Exchangers—Table I

		Outer Tube Limit		
Shell Outside Diameter	Shell Inside Diameter	Fixed Tube Sheet	Outside Packed Head	Internal Floating Head
5.563 in.	5.047 in.	4.625 in.	3.500 in.	3.594 in.
6.625	6.065	5.625	4.500	4.625
8.625	7.981	7.594	6.407	6.563
10.75	10.020	9.625	8.469	8.563
12.75	12.000	11.625	10.438	10.563
14	13.25	12.875	11.688	11.813
16	15.25	14.875	13.688	13.813
18	17.25	16.875	15.688	15.813
20	19.25	18.875	17.688	17.813
22	21.25	20.875	19.688	19.813
24	23.25	22.875	21.688	21.813
26	25	24.625	23.438	23.563
28	27	26.625	25.438	25.563
30	29	28.625	27.438	27.563
32	31	30.625	29.438	29.563
34	33	32.625	31.438	31.563
36	35	34.625	33.438	33.563
38	37	36.625	35.438	35.563
40	39	38.625	37.438	37.563
43	42	41.625	40.438	40.563

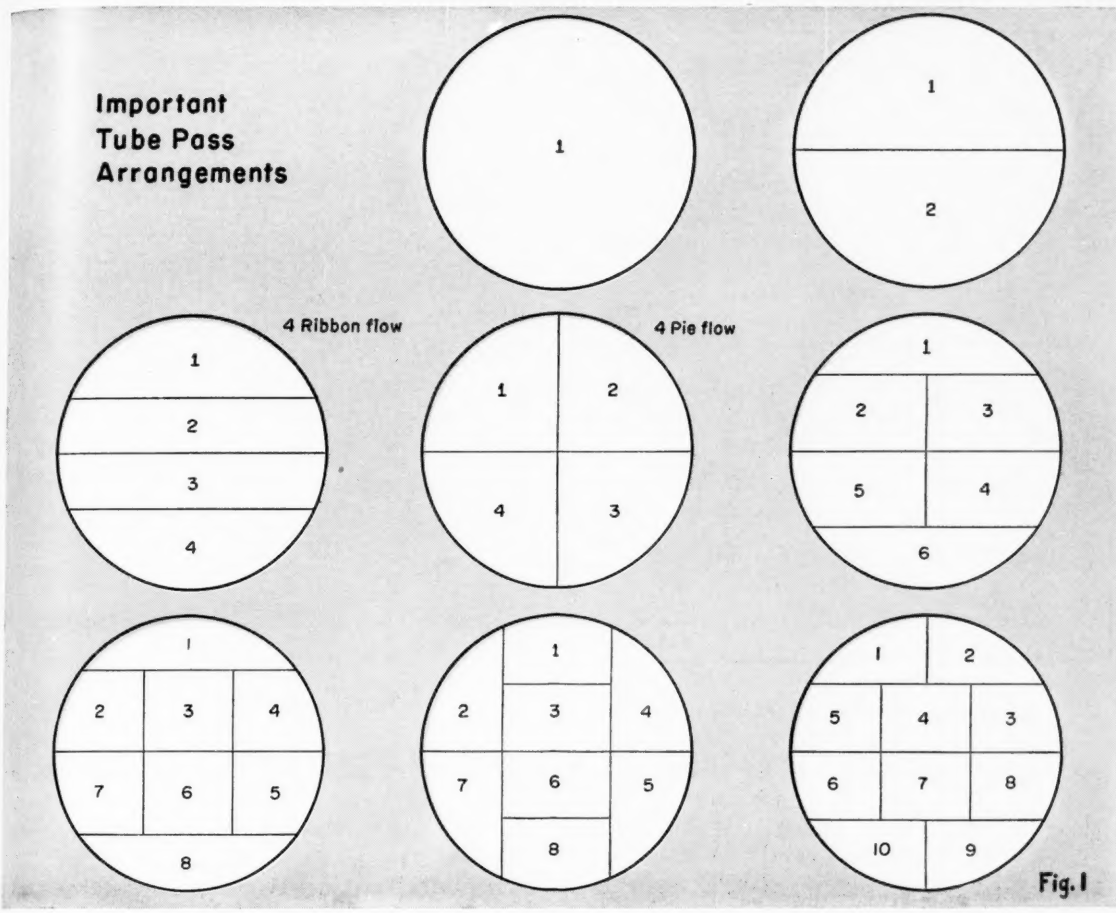
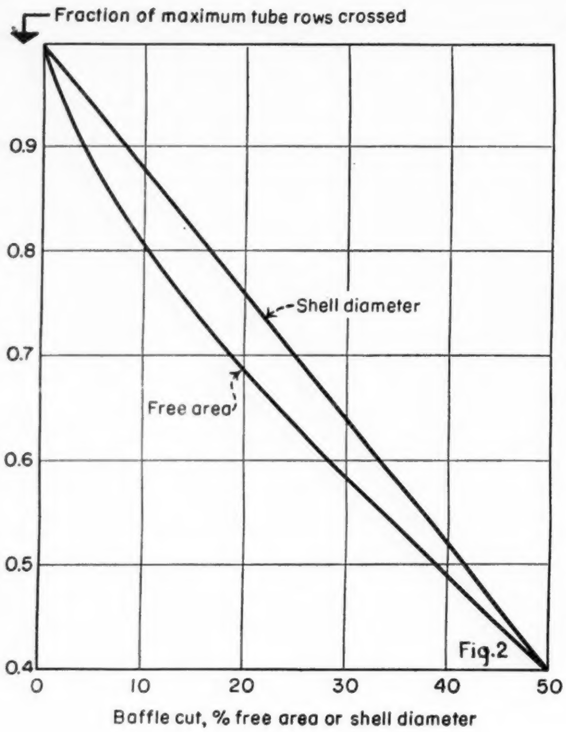


Fig. 1

Cross-Flow Clearances for Heat Exchangers—Table II †

Shell Inside Diameter	Fixed Tube Sheet						Internal Floating Head					
	15/16-in. Pitch 3/4-in. Tubes		1-in. Pitch 3/4-in. Tubes		1 1/4-in. Pitch 1-in. Tubes		15/16-in. Pitch 3/4-in. Tubes		1-in. Pitch 3/4-in. Tubes		1 1/4-in. Pitch 1-in. Tubes	
	1, 2, 4R Passes	4-Pie, 6 Passes	1, 2, 4R Passes	4-Pie, 6 Passes	1, 2, 4R Passes	4-Pie, 6 Passes	1, 2, 4R Passes	4-Pie, 6 Passes	1, 2, 4R Passes	4-Pie, 6 Passes	1, 2, 4R Passes	4-Pie, 6 Passes
5.047 in.	1.297 in.	2.047 in.	2.047 in.	2.047 in.	2.047 in.	3.047 in.	2.047 in.	3.547 in.	2.797 in.	3.547 in.	2.047 in.	3.047 in.
6.065	1.565	3.065	2.315	3.065	2.065	2.065	2.315	3.065	3.065	3.065	3.065	4.065
7.981	1.981	3.481	2.731	3.481	1.981	3.981	2.731	3.481	3.481	3.481	2.981	3.981
10.02	2.52	4.02	3.27	4.02	3.02	4.02	3.27	4.02	4.02	4.02	3.02*	4.02
12.00	3.0	4.50	3.75	4.50	3.00	4.00	3.75	4.50	4.50	4.50	4.00	4.00
13.25	3.5	4.25	3.50	4.25	3.25	3.25	4.25	4.25	4.25*	5.75	4.25	5.25
15.25	3.25	4.75	4.0	4.75	3.25	5.25	4.75	4.75	4.75	6.25	4.25	5.25
17.25	3.75	5.25	4.5	5.25	4.25	5.25	4.5*	5.25	5.25	6.75	5.25	5.25
19.25	4.25	5.75	5.0	5.75	4.25	5.25	5.0	5.75	5.75	7.25	5.25	5.25
21.25	4.75	6.25	5.5	6.25	5.25	5.25	5.5	6.25	6.25	7.75	5.25	7.25
23.25	5.25	6.75	6.0	6.75	5.25	5.25	6.0	6.75	6.75	8.25	6.25	7.25
25	5.5	7.0	7.0	7.0	6.0	7.0	6.25	7.0	7.75	8.5	6.0	7.0
27	6.0	7.5	7.5	7.5	6.0	7.0	6.75	7.5	8.25	9.0	7.0	7.0
29	6.5	8.0	8.0	8.0	6.0	7.0	7.25	8.0	8.75	9.5	7.0	9.0
31	7.0	7.0	8.5	8.5	7.0	7.0	7.25	8.5	9.25	10.0	8.0	9.0
33	6.75*	7.5	9.0	9.0	7.0	9.0	8.25	9.0	9.75	10.5	8.0	9.0
35	7.25	8.0	9.5	9.5	8.0	9.0	8.0*	9.5	10.25	11.0	8.0	9.0
37	7.75	8.5	10.0	10.0	8.0	9.0	8.5	10.0	10.75	11.5	9.0	9.0
39	8.25	9.0	10.5	10.5	8.0	9.0	9.0	10.5	11.25	12.0	9.0	11.0
42	9.0	10.5	11.25	12.0	9.0	10.0	9.75	10.5	12.0	12.0	10.0	10.0

† All dimensions in inches. * Add tube o. d. for 2, 4 pass layout.



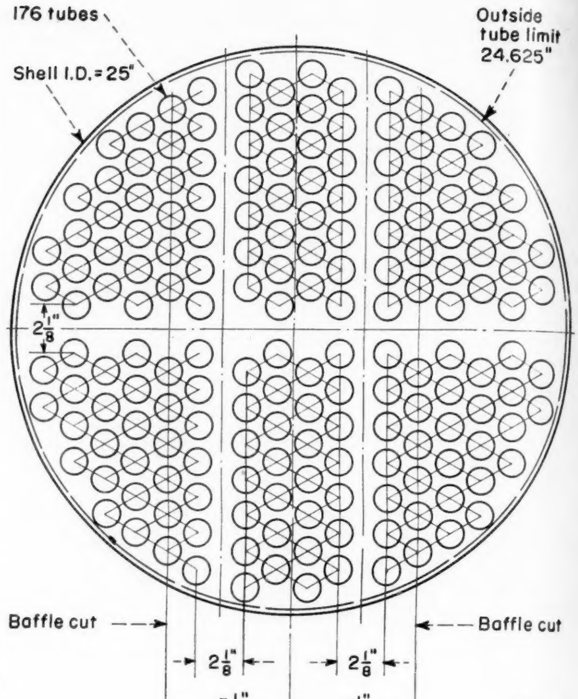


Fig.3

obtained by using Fig. 2 without reference to any actual tube layout.

Maximum number of tube rows crossed is assumed to equal the internal shell diameter divided by the tube spacing for square pitch.

For triangular pitch with flow into the 60° angle, the maximum number of tube rows crossed is assumed to equal the shell I.D. divided by 0.866 times the tube pitch or spacing.

This maximum number of tube rows crossed has to be multiplied by the correction factor from Fig. 2. You can use either the baffle cut as the % of the net free area of the tube bundle or as a percentage of the shell diameter.

A Typical Problem

A 16-in. O.D. internal floating head heat exchangers has ¾-in. o.d. tubes arranged for six tube passes on a 1-in. triangular pitch. Baffle cut is 33% of net free area. Baffle spacing is 4 in. Determine area for cross flow and number of tube rows crossed by the fluid at each baffle space.

First, the cross flow area can be calculated by multiplying the value of 6.25 from Table II by 4. Cross flow area is 25 sq. in.

Number of tube rows crossed = $(15.25/1\times0.866)\ (0.55^*) = 10$.

Another Problem

A 25-in. I.D. fixed tube sheet heat exchanger has 176 tubes of 1¼-in. o.d. arranged for six tube passes on a $1\frac{9}{16}$-in. triangular pitch. Baffle cut is 25% on net free area. Baffle spacing is 6 in. Determine (1) area for cross flow, (2) area for longitudinal flow at baffle and (3) number of tube rows crossed by fluid at each baffle space.

From Table I: *O.T.L.* is $24\frac{5}{8}$ in. and
$O.T.C. = 24\frac{5}{8} - 1\frac{1}{4} = 23\frac{3}{8}$ in.
$B = S + o.d. = \frac{7}{8} + 1\frac{1}{4} = 2\frac{1}{8}$ in.

From Eq. (3)
No. tubes at center

$$\left[\frac{(23.375 - 2.125)}{2(1.5625)} + 1\right]2 = 14$$

From Eqs. (4) and (5)
Blocked center distance =
$1.25 \times 14 = 17.5$ in.
Clearance =
$25 - 17.5 = 7.5$ in.

* From Fig. 2.

Crossed flow area =
$6 \times 7.5 = 45$ sq. in.
Total internal shell area =
$25^2 \times 0.786 = 492$ sq. in.
Tube area =
$176 \times 1.25^2 \times 0.786 = 216$ sq. in.
Net free area $= 276$ sq. in.
Area for longitudinal flow =
$0.25 \times 276 = 69$ sq. in.
No. tube rows crossed =
$[25/(1.5625 \times 0.866)](0.63^*) = 12$

Graphical Solution

The tube layout of Fig. 3 was prepared for the above problem. The baffle cut is located at the midpoint of the fourth row of tubes above the center line. The net free area calculates as 22.5%. Note that the baffle cut as a percentage of shell diameter is $(6.938/25.0)100 = 28\%$.

The mid-point of the net free area calculates as being slightly above the center line of the sixth row of tubes above the center line. Thus the fluid crosses 12 rows of tubes at each baffle space. This checks the data calculated.

REFERENCES

1. Rubin, F. L., *Chemical Engineering*, p. 202, May (1953).

Cumulative Tabulation Reports Past and Present Status

Work begun

Week Ending	Units* Completed	Percent Completed	Man-Hr. Completed	Weekly Performance Ratio	Men Assigned	Actual Man-Hr. Remaining Based on Current Pref. Ratio
15 16 17 18 19 **20** 21	715	7.15	800	0.895	20	10,380
22 23 24 25 26 **27** 28	1,830	18.3	2,000	0.93	30	8,790
29 30 31						
FEBRUARY						
1 2 **3** 4	3,008	30.1	3,200	0.94	30	7,450
5 6 7 8 9 **10** 11	4,113	41.1	4,400	0.92	30	6,400
12 13 14 15 16 **17** 18	5,263	52.6	5,600	0.96	30	4,930
19 20 21 22 23 **24** 25	6,378	63.8	6,800	0.93	30	3,900
26 27 28 29						
MARCH						
1 **2** 3	7,433	74.3	8,000	0.88	30	2,920
4 5 6 7 8 **9** 10	8,169	81.7	8,800	0.92	20	1,980
11 12 13 14 15 **16** 17	8,889	88.9	9,600	0.90	20	1,235
18 19 20 21 22 **23** 24	9,584	95.8	10,400	0.87	20	478
25 26 27 28 29 **30** 31	9,966	99.7	10,800	0.85	10	40
APRIL						
1 2 3 4 5 **6** 7	10,014	100.0	10,880	0.60	2	......

Work completed

TO HIT TARGET DATE . . .

Control Your Construction Schedule

You can log actual progress vs. estimated progress and adjust labor assignments to meet construction schedules. Key is the ratio of actual to estimated labor units as job progresses.

M. NADEL, Day & Zimmermann, Inc., Philadelphia, Pa.

How do you measure on-the-job variables so that you can adjust your labor force to meet the specified completion date for a plant construction project?

On a recent assignment, we found one very effective answer in the use of performance ratio. This is the ratio of labor units completed to hours of labor actually expended. By charting our progress in terms of performance ratio at the end of each week, we could adjust our manpower assignments to meet the schedule.

Preconstruction planning is valuable for distributing men and materials. But it cannot take into account on-the-job variables of labor force, weather conditions, site conditions, job conditions and management at the job site.

*Meet your author on page 320.

In performance ratio, we have found a system to correlate these variables so that we know how much they affect the job progress. Conversely, if we know a given set of job conditions we can estimate job requirements on a sound basis by using a job efficiency based on previous jobs.

We shall use a process-piping job as an example. With modifications, the same general system can be applied to structural, electrical, building service and erection work. The main prerequisite is that the work be amenable to analysis in terms of units of labor.

Estimate Total Cost

In the final phase of engineering a piping job, it is necessary to estimate the total plant cost in detail so that the owner can appropriate funds. Such an estimate includes all labor, material, supervision, and interest on capital investment.

On a piping job, we usually make a detailed "take-off" by types of piping and plant areas to show all pipe, fittings, valves and supports that we'll need to complete the project.

Then, unit material costs are obtained from vendors. These are applied to the "take-off" and extended to give total material costs.

We get labor costs by applying man-hr. figures for: handling and erection, including receiving, warehousing and transfer to the point of use in place ready for joining; joining, including preparation such as cutting, threading, cleaning, beveling, and making the joint by welding, screwing and bolting; and

Weekly Report Sums Up Progress Of Piping Job

JANUARY

15 16 17 18 19 20 21

Work begun

First report

Area: Acid
Date: 1/20/56

Estimated total labor units		
Steel		5,000
Glass-lined steel		2,500
Glass		2,500
		10,000
Completed total labor units		
Steel		380
Glass-lined steel		175
Glass		160
		715
Percent completion, 1st week (715/10,000) (100) = 7.15%		
Total labor man-hr. spent this week		
Steel	10 men	400 man-hr.
Glass-lined steel	5 men	200 man-hr.
Glass	5 men	200 man-hr.
Over-all labor performance ratio		
(Labor units completed)/(labor hours spent) = 715/800 = 0.895		
Labor ratio by materials		
Steel		380/400 = 0.950
Glass-lined steel		175/200 = 0.875
Glass		160/200 = 0.800
Adjusted labor remaining (10,000–715)/0.895 = 10,380 man-hr.		

hanging, including fabrication of supports other than bridges or trenches and securing the pipe.

These labor figures usually are obtained through an experience factor or by consulting the many papers on this subject. These figures can be extended to give the total number of man-hr. needed to complete the work. The dollar figure can be derived quite readily based on local labor rates.

Check Progress Against Estimate

Now, we shall see how performance ratio can be used to control the construction schedule for piping the acid area of a plant.

Labor required to install piping in this area is estimated at 10,000 man-hr. A breakdown of this total shows 5,000 man-hr. allocated for steel pipe and 2,500 man-hr. each for glass-lined-steel pipe and glass pipe. We have arranged with the labor supervision to log separate labor time for these materials.

In the course of the first week's work, our supervision has assigned 20 fitters to this area to run the main headers and rack piping. Our Field Engineers have marked up the piping drawings daily to indicate which lines have been installed and to check that the drawings and specifications have been followed.

At the end of the first week, the amount of work completed on each type of piping is determined from the marked-up drawings. Since there was no prefab shop work on this job, no allowance has to be made for this factor.

Unit figures for labor are taken from the original estimate to give Labor Units Completed for each piping category. Actual labor expended also is subdivided into the same categories. Labor unit is the estimated amount of work that one man should complete in one hour.

On the Weekly Report you see the summary of piping activity for one week. Percent completion is calculated as the ratio of labor units completed to the estimated total labor units for the job.

Labor performance ratio is a measure of labor units completed per man-hr. of work. If the amount of work actually done per hour were the same as estimated, the ratio would be unity. The deviation from unity might be attributed to any one or combination of job variables and/or error of the original estimate.

The breakdown of labor ratio by materials is given to help in adjusting the estimator's unit figures.

Based on the week's performance ratio, the actual adjusted labor remaining is $(10{,}000 - 715)/0.895 = 10{,}380$ man-hr.

Subsequent weekly reports could be tabulated together as shown, p. 261.

A graphical plot of these data would give curves for Estimated Progress and Actual Progress. The curve for the former is based on completion of one labor unit per man-hr. For the latter, the curve reflects the adjustment indicated by the performance ratio.

With this information, supervision can adjust manpower assignments continuously to meet construction schedules. Shifting of the performance ratio will reflect the effect of variables such as dearth or excess of labor, location of work, weather conditions, quality of supervision and material status, to mention a few. Variations in job conditions should be logged for use later to explain fluctuations in performance ratio.

These data may be compared with the manpower schedule proposed prior to construction and with the estimating data used to draw up the schedule. Then, data used for estimating may be adjusted so that future jobs will reflect the experience gained.

On a recent assignment, we found this method most effective for establishing and adjusting manpower schedules. It makes possible close control of any construction project.

GAS-LIQUID CONTACTING IN RANDOM-PACKED TOWERS

Flow Through Packings and Beds

First of two articles on gas-liquid flow through random-packed towers, this deals primarily with equipment components including the packing and its installation, the packing support and the liquid distributor.

MAX LEVA, Consulting Chemical Engineer, Pittsburgh, Pa.*

Last month (*Chemical Engineering*, Jan. 1957, p 204) we surveyed the scope of this series on fluid flow through packed towers and fixed, moving-bed and fluidized reactors.

The present article marks the actual beginning of the series. Purely on the basis of the number of participating phases a convenient and logical classification suggests itself. Thus flow through packed towers generally involves two phases—gas-liquid or liquid-liquid. On the other hand, flow through various types of reactor systems is usually a single-phase phenomenon. This and the succeeding article will deal exclusively with gas-liquid flow through random-packed towers.

How the Series Is Organized

- **Random packed towers**
  - **Gas-liquid systems**
    - **Characteristics of tower components**
      - Dumped-type packings
      - Placement of packings in tower
      - Packing supports
      - Liquid distributors
  - **Liquid-liquid systems**
- **Stacked towers**
  - **Gas-liquid systems**
- **Reactors**
  - **Fixed bed**
  - **Moving bed**
  - **Fluidized bed**

Two-Phase Flow

Fundamental considerations will show that the interpretation of two-phase flow phenomena is considerably more complex than that of single-phase flow problems. In single-phase flow it is merely required to propose a working model that describes the effect of bed configuration on one single phase. In two-phase flow, however, it is necessary to consider not only the effect of bed configuration on fluid passage alone but also the mutual effects which the phases exert on each other. This will become quite apparent from future discussions of two-phase pressure drop. In addition to the interaction of phases, there may also be a separate effect of one phase such that the apparent characteristics of the bed appear to be changed. For instance, it is known that gas pressure drop through a packed column is dependent on particle size and particle shape. But in addition to this, holdup of a liquid phase in the bed may alter the effective size and shape of the individual packing elements. Hence the characteristics of the interstitial voids and the resistance to flow of the other phase will be changed.

From this consideration, another broad characteristic of two-phase flow becomes apparent. Thus, in any packed system which carries two phases simultaneously, one phase must be *discontinuous* in order to permit the other phase to be *continuous*. Whenever conditions are such that the discontinuous phase tends to become continuous, the originally continuous phase must by necessity become discontinuous.

Consequently, the flow pattern in the tower will change. As these conditions are usually approached, the system tends to become unstable. If we examine the reasons for an impending change, we will observe the following. The liquid phase—although originally discontinuous—may become continuous either through increased liquid flow rates, or because the gas flow rate has been increased sufficiently to increase holdup. In either case a change from discontinuity of flow of the liquid to continuity will occur.

Nomenclature

D_p	**Diameter of a sphere of volume equivalent to the particle, ft.**
f	**Modified friction factor (Fig. 1).**
g_c	**Conversion factor, 32.2 (lb. mass/lb. force) (ft./sec.^{2}).**
G	**Mass velocity of gas, based on vessel cross section, lb./(sec., sq. ft.).**
H	**Height of packing in column, ft.**
L	**Liquid flow rate, lb./(sec., sq. ft.).**
n	**State-offlow factor, see Fig 2**
N_{Re}	**Modified Reynolds number, D_pG/μ.**
Δp	**Pressure drop, lb./sq. ft.**
ϵ	**Fractional voids in bed, dimensionless.**
ϕ_s	**Shape factor (see *Chem. Eng.*, May 1949, p. 115).**
ρ_F	**Fluid density, lb./cu. ft.**

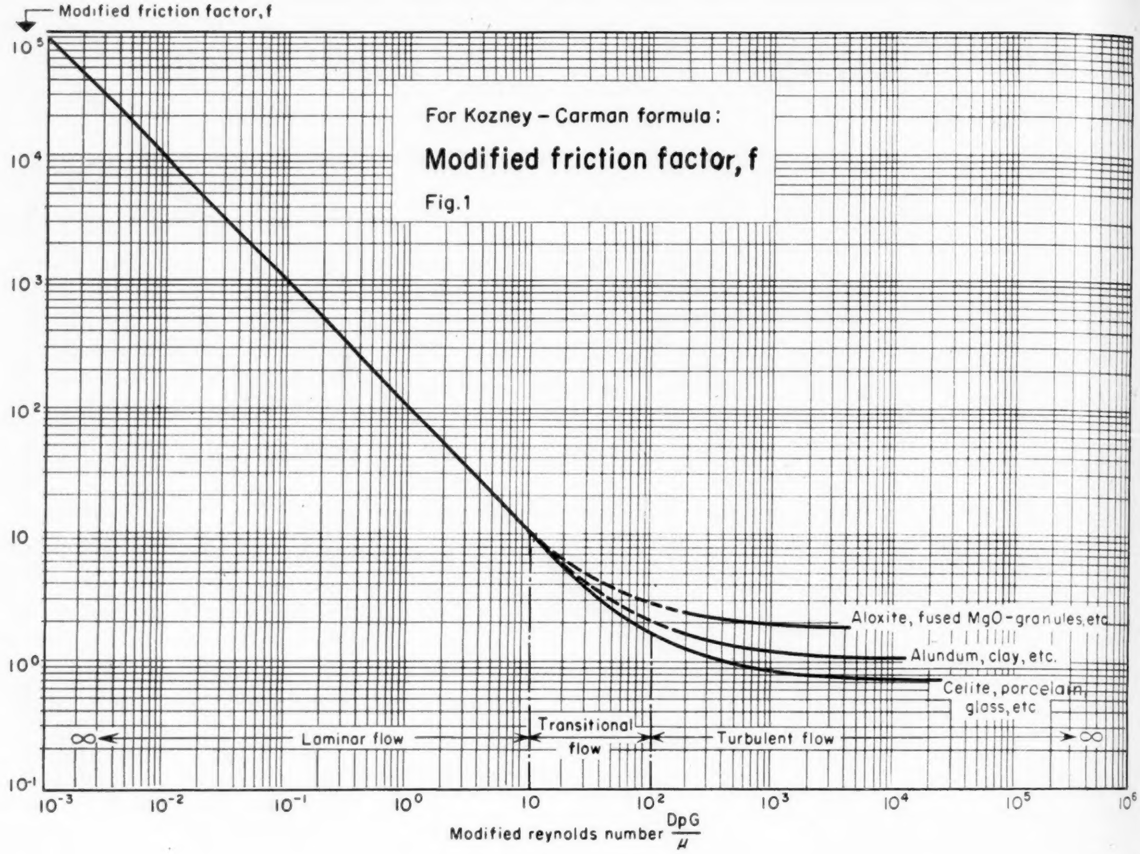
Single-Phase Flow

A brief discussion of single-phase-flow data correlations will be helpful for a better understanding of a possible mechanism of two-phase-flow systems. Among the many approaches towards a suggested mechanism and model for flow through broken solids, the methods of Kozeny and Carman have probably yielded the most useful working equations. Thus single-phase-flow data through packed systems were correlated by

$$\Delta p = \frac{2f\,G^2\,L\,(1-\epsilon)^{3-n}}{D_p \phi_s^{3-n} g_c\,\rho_F \epsilon^3} \qquad (1)$$

In this equation f denotes a modified friction factor and n is termed the state-of-flow factor. Both may be expressed as functions of a modified Reynolds number $D_p\,G/\mu$, and the relationships are indicated in Fig. 1. The state-of-flow factor varies from unity for laminar flow, to 2.0 as a limit for turbulent flow.

*For author biography see *Chem. Eng.*, Jan. 1957, p. 294.



For Kozney – Carman formula:

Modified friction factor, f

Fig. 1

For $N_{Re} < 10$ the flow is laminar. At higher values the state of turbulence continues to increase. As will be demonstrated in later discussions, Eq. (1) together with Fig. 1 are useful for examination of flows in fixed as well as, up to a certain point, fluidized systems.

Two-Phase Flow

In the case of two-phase flow, this equation is applicable only over a very limited range. If the rate of flow of the discontinuous phase is so low that the resulting holdup will affect bed voidage only nominally, then reasonably accurate pressure drop predictions are possible with Eq. (1). Beyond certain liquid flow rates, merely to correct Eq. (1) for voidage will not suffice, because at higher irrigation rates the effective shape of the particles will also be altered. In addition, there will be energy expenditures for penetrating and disrupting liquid streams, as well as for lifting liquid droplets.

All of these phenomena are not taken into account by Eq. (1). As a consequence, the single-phase correlation will predict pressure drops lower than those observed, once the liquid rate approaches the so-called loading zone.

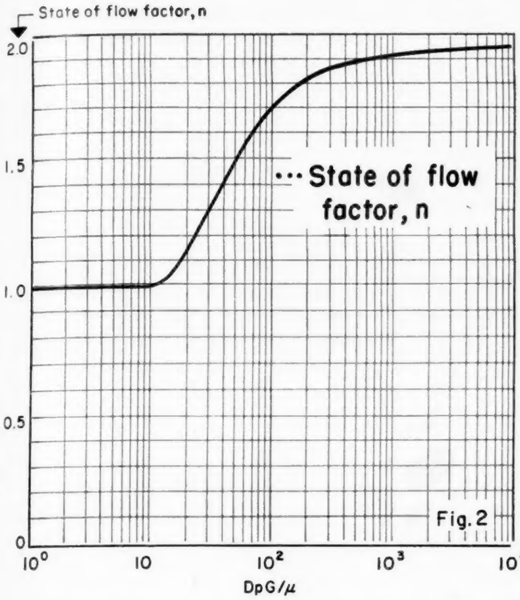
Virtually all two-phase packed towers operate under gas rates such that the resulting modified Reynolds number D_pG/μ is well in excess of 200. For this reason one would expect that plots of log Δp versus log G (for low irrigation rates below the loading zone) would yield straight lines of approximate slopes of 1.8 to 2.0 in the limit. At the loading point, a substantially larger portion of liquid is held up in the packing than would ordinarily be expected from the liquid flow rate. What actually happens is that liquid and gas flows reach rates such that interphase effects become important.

This interaction, which depends on fluid rates and the character of the packing, is apparent from a study of Fig. 3. Above the loading zone; the discontinuous nature of liquid flow tends to become modified and eventually a greater degree of continuity results, leading to the so-called flooding point.

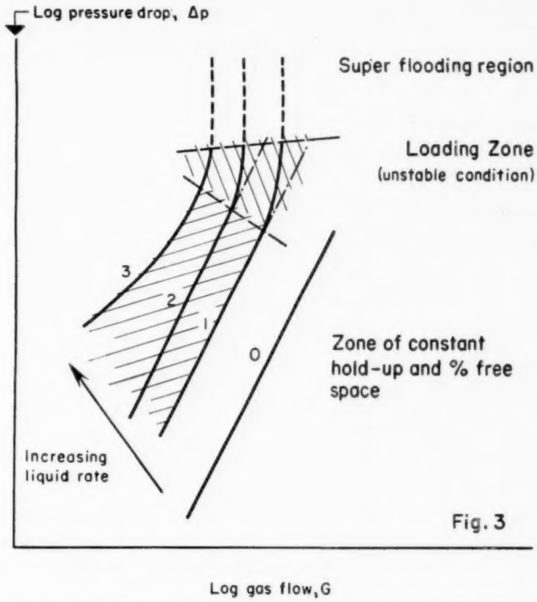
These relationships are briefly reviewed here because they are essential to an understanding of the resulting correlations for two-phase gas-liquid flow through packings. It is also well to note that virtually all working correlations for two-phase gas-liquid flow are chiefly empirical and most relationships lack dimensional homogeneity. Nevertheless, it should be emphasized that the correlations are very reliable and their validity extends to a wide range of diversified conditions.

Packed-Tower Equipment

The basic elements that comprise a packed tower are (1) packing, (2) shell, (3) packing support, (4) liquid distributor and, in some



Here Reynolds number determines the type of flow. Appropriate values for modified friction factor f and state of flow factor n are found for use in Eq. 1.



Characteristic pressure drop in packed towers with two-phase flow. Loading points appear at lower boundary of loading zone. Upper boundary shows flooding points.

Characteristics and Uses of Dumped Packings

Kind	Available in Nominal Size Range, Inches	Available Materials of Construction	Special Features	Predominant Use
Raschig rings	¼ to 3	Chemical stoneware, porcelain, carbon and metal (i.e. carbon steel, stainless steel, copper, aluminum)	Outside diameter of ring is equal to ring height. Material permitting, packing is extruded.	Used in gas absorption, distillation, liquid-liquid extraction, on commercial as well as laboratory scale.
Lessing rings	Up to 2	Ceramics, metals and carbon	A raschig ring with an additional web in center.	Same as raschig rings. Capacity data and pressure drops possibly somewhat higher than those of raschig rings.
Pall rings	....	Metal	A raschig ring with portions of sides deformed inward.	Absorption and distillation. Performance possibly superior to raschig rings.
Berl saddles	¼ to 2	Chemical stoneware and porcelain	Hyperbolic paraboloid shape, requiring dry pressing manufacturing methods.	Same as raschig rings, but usually will yield somewhat improved capacity data and pressure drops.
Intalox saddles	¼ to 2	Chemical stoneware and porcelain	Torus shape, lending itself well to protrusion manufacturing methods.	Same as raschig rings. Of all ceramic dumped-type packings they give highest capacity data and lowest pressure drops.
Cannon packing	0.16×0.16 and 0.24×0.24	Metals	A part-ring shape, carrying protruded holes.	Principally used in laboratory or bench scale distillation columns.
Tellerette	1 and 2	Polyethylene	A helix joined on ends to form a doughnut.	High voidage packing, said to function on interstitial holdup.

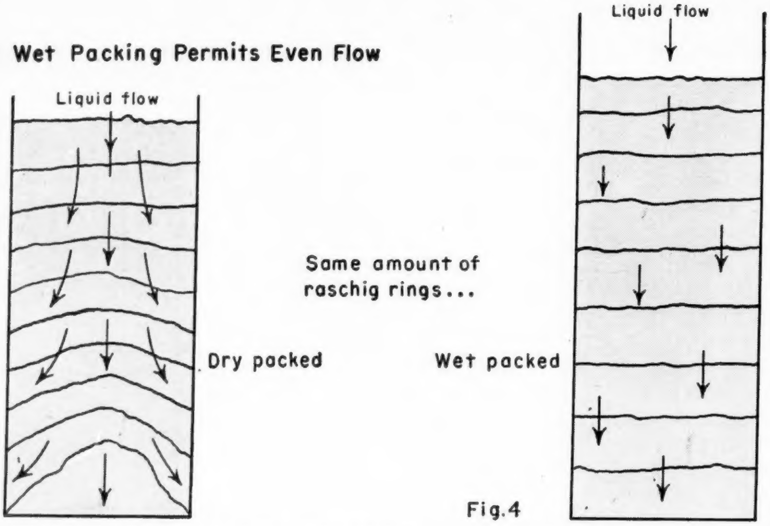


Fig. 4

Conical contours result when raschig rings are dry-packed, direct liquid flow to wall. Increase in voids is obtained by wet-packing the same amount of rings.

cases, (5) liquid redistributors. Also required are gas and liquid pumping equipment, sometimes spray eliminators and of course a tower foundation. All of these items must be considered in the design and the economics of the system.

Packings—The packing is by far the most important component of the system. The efficiency of the packing with respect to both HTU and flow capacity determines to a significant extent the over-all size of the tower. It may also determine the type of gas pumping equipment. The economics of the installation is therefore intimately tied up with packing choice.

Packings are either dumped or stacked into towers. In general, rings of less than 2-in. nominal size are always dumped. The 2-in. size ring is infrequently stacked, and the 3-in. size more frequently. Rings above this dimension are always stacked. Also, there are special types of rings and grids that are always stacked. The question of whether to dump or stack packing is inherently associated with the gas quantity to be handled. When very large gas quantities are handled pressure drops must be low. Then stacked packings are indicated. However, stacked packings will lead to low capacity data, so a check on tower height should be made.

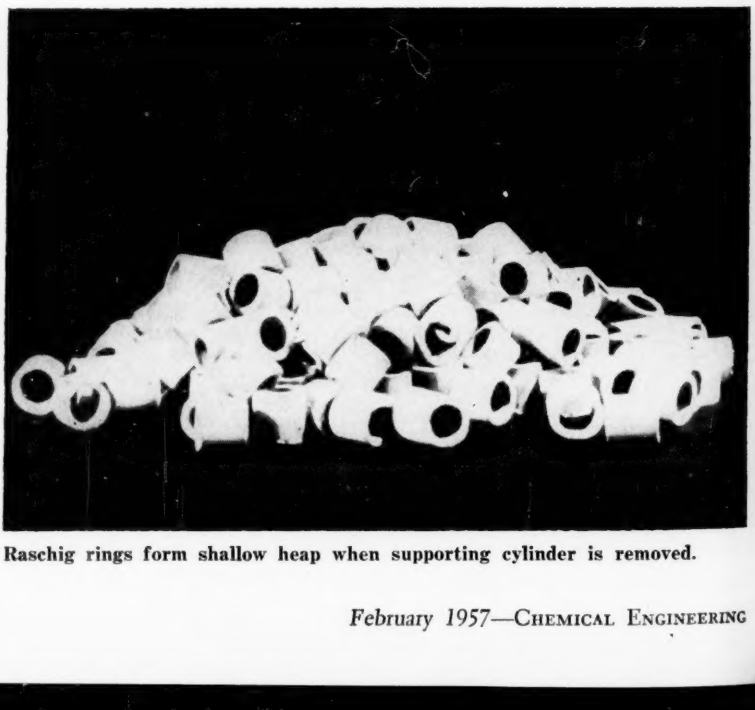
Although many different types of packings have been suggested over the years, relatively few have been developed for industrial applications. Broadly speaking, the chemical process industries have limited their consideration mainly to certain types of rings and saddles, a few special types of metallic packings of definite design and a few grids. The table gives a quick survey of dumped-type packings.

The earliest packings used in the process industries were irregularly shaped bodies of inert rock or coke. Although these materials were inexpensive, experience has indicated that process costs were high with them, as reflected by high pressure drops, non-reproducible conditions, and contamination of process streams. This has led to the development of the specially shaped bodies indicated in the table. Ceramic packings may be manufactured by either dry pressing or extrusion methods. The latter are preferable as far as quality and resulting density of the construction material is concerned. Furthermore, extrusion is also more economical than dry pressing.

Preparing the Bed

In a dumped packing installation special attention must be given to the method of preparing the bed. Excessive breakage of the ceramic material is avoided by packing the towers "wet." This is done by filling the tower to about 60% of its height with water and allowing the packing pieces to tumble through the water column and thus come to rest in a random arrangement. The wet-packing method will invariably produce a column of higher porosity than a careful dry packing procedure. Thus a column packed wet with 1-in. Raschig rings may have a voidage of 75%, while the same column packed dry may exhibit only 70% or less free space.

Just how significantly this differ-

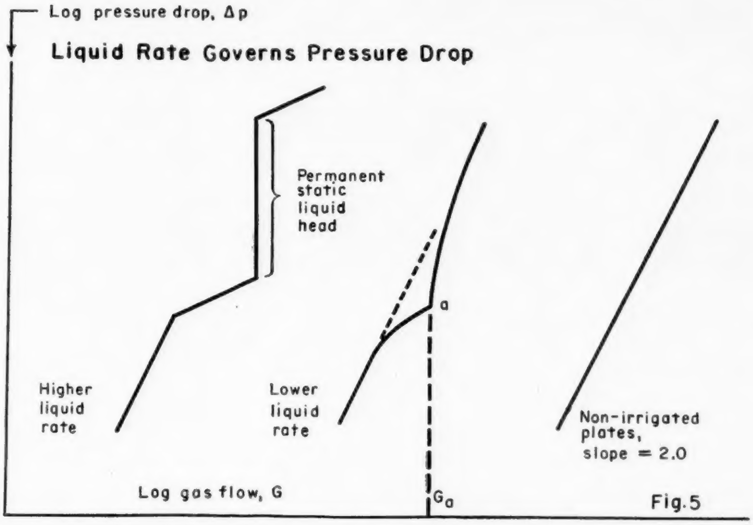


Raschig rings form shallow heap when supporting cylinder is removed.

ence will affect pressure drop may be estimated from the relation $\Delta p \propto (1-\epsilon)/\epsilon^3$, for turbulent flow. Thus, considering the above values of the voidage ϵ, a decrease in free space from 75 to 70% will increase the pressure drop by about 48% if we assume the tower is not (or only relatively little) liquid irrigated. In time, the packing will settle in the shell, hence the pressure drop will increase.

Although this later pressure drop increase is generally not desirable, wet packing with rings does yield another important advantage. Unless special precautions are followed in dry-packed beds, the rings will assemble along a certain pattern as indicated in Fig. 4. This pattern is to be avoided if at all possible in order to preclude the tendency of flow towards the wall. The wet-packing method results in a more random packing pattern in which the strata are nearly horizontal as shown in Fig. 4.

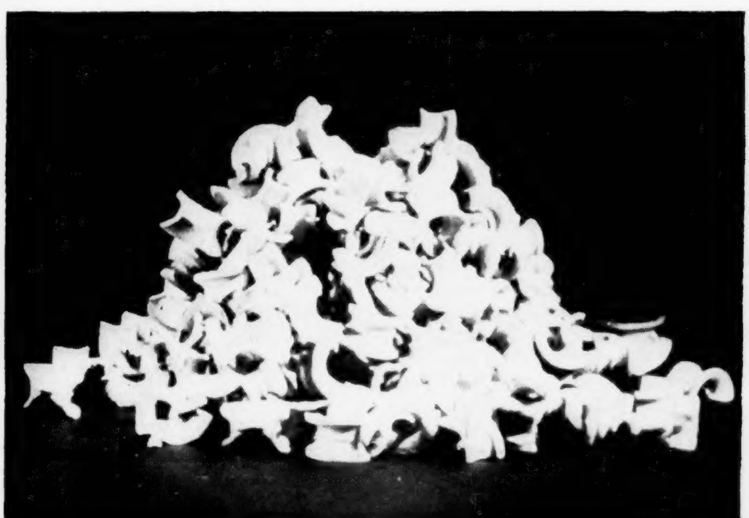
The settling of packing in the tower may become a serious matter if the unit is periodically subjected to temperature changes. This may well occur during regular operating cycles as a consequence of start-ups and shut-downs. Under such varying thermal conditions the tower shell may expand sufficiently to permit substantial settling of the packing. Thereafter, upon cooling, the shell will recontract giving rise to internal breakage of the packing.



Temporary liquid head forms at point *a* for the lower liquid rate and gas rate G_a. At higher liquid rate a permanent static liquid head is established.

Rings are particularly susceptible to this difficulty because individual ring elements have no mutual interlocking characteristics. For this reason they do not generally yield very stable columns.

This point is particularly well shown below where a column of 1-in. Raschig rings (left view) was placed in a bottomless glass cylinder, resting on the floor. As would be expected, after the cylinder was slowly and carefully raised, the rings rolled all over, yielding only a very shallow heap. For comparison the same experiment when carried out with 1-in. Intalox saddles (right) yielded a much steeper pile. This simple experiment demonstrates the relative extent of shifting that may be expected in towers. Obviously, the more stable saddle-packed column assures better operational reproducibility.



Under the same conditions Intalox saddles result in steeper pile.

Packing Supports

The function of the packing support is to hold the packing in place. Also, packing-support plates must provide sufficient free space under actual operating conditions to permit unrestricted countercurrent exchange of gas and liquid. Conventional flat-plate supports of up to 50% free space will frequently lead to difficulties, because the adjacent first layer of packing may obstruct the ports. Since flat ceramic plates of more than 50% free space may not be considered strong enough to support heights of packing frequently used in commercial towers, special developments are required. In the past—where metal construction has been permissible—steel grids with large openings have been employed, carrying an initial few layers of a larger size cross-partition rings, to support the dumped packing proper.

Considering the mechanism of gas-liquid flow that is met with

Weirs Prevent Liquid Buildup

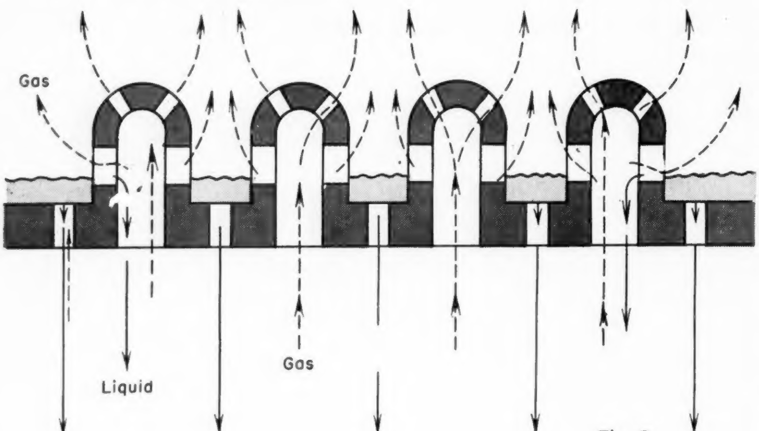


Fig. 6

Weir-type plates produce low pressure drop and show no flow disturbance. Also separate passage for gas and liquid flow prevent bottom flooding.

support plates (Fig. 5), and where simultaneous gas-liquid passage must occur through the same openings, a special construction called the Weir-type plate (Fig. 6) was developed. Its functioning as indicated in the sketch is such that it provides for gas and liquid countercurrent passage via separate paths. Thus the liquid leaves essentially through the openings in the base and the gas phase is distributed evenly by way of the risers. Certain fluid rates using conventional plates may cause excessive local pressure drops and possibly bottom flooding. For the same flow rates using Weir-type plates, merely a fraction of the pressure drop occurs and there is no indication of any flow disturbance. The pressure drop through Weir-type plates is in fact so low that it may for all practical purposes be neglected in tower design calculations.

Liquid Distributors

Performance and efficiency of packed towers may depend markedly on the choice and design of liquid distributors. This is particularly true when the irrigation rate to the tower is small, say below 1,000 lb./(sq. ft., hr.). For larger liquid flow rates the problem is less severe. Liquid distributors operate generally more satisfactorily with large than with small flows. Also, at larger liquid flow rates, the packings are more readily wetted and the uppermost zone of a dumped packing in the tower can be counted on to act as its own distributor for the lower packing region.

In general, we may state that the satisfactory operation of liquid distributors is somewhat limited by definite flow rates. Considering a central pipe and feeder system, where individual liquid streams pass through small orifices, it is obvious that the openings on the outer periphery of the feeder system will function only for a certain minimum liquid rate. At maximum flow, there is no limitation from the point of view of the number and location of orifices. However, excessive pressure drops through the orifices will set the limit. Distributors of this type require liquid strainers ahead of the orifices. Pressure drops through this type of distributor may be estimated by using standard orifice correlations.

Overflow-type distributors are more commonly used than pipe feeder systems. Their operation is less dependent on a definite liquid range. Also, they are less susceptible to interruptions due to deposits. The number of streams per unit of tower cross-section is of course dependent on the liquid flow rate, the type of packing and also the packed height. It has been found that between one and three streams per square foot of tower cross-section are satisfactory for most applications. Special arrangements are frequently required in fractionating columns where relatively small amounts of reflux have to be returned. In the case of gas passage it is desirable to provide separate gas chimneys. Better still, the gas may be allowed to pass through the annular space when distributor plates of diameters smaller than the tower diameter are used.

In addition to the overflow-type of distributor, there are other similar designs where the overflow to the packing occurs through specially designed patterns. These are most frequently employed with special grid-type packing and may be briefly considered later.

Packed columns are usually built in individual sections, varying from as low as 5 ft. to perhaps 20 ft., or more. The chief reason for sectioning the column is the desire to redistribute the liquid in the packing and thus to maintain a high level of packing performance. Usually it is not satisfactory to interrupt a packed column by an ordinary packing support. The packing support may have many openings blocked by packing—and thus inactive—so it cannot be expected to act as a liquid distributor as well. If an ordinary packing support is used, it must be followed up by an overflow type distributor. This combination will render a substantial portion of the shell inactive as far as packing holding function is concerned. Hence, it is advisable to eliminate this combination, instead using a Weir-type support plate. This device also operates very satisfactorily as a redistributor. Furthermore, the combined cost of packing support and redistributor will most likely exceed the cost of the Weir-type plate.

COMING

Next month, the series presents correlations of gas-liquid flow in packed towers. A modified Kozeny-Carman equation enables you to predict the pressure drop in non-irrigated systems. Empirical relations are explained and equations for use with irrigated towers given.

Comparison of the effective voidage and surface area utilization of various packings is developed. Additional relations are given on liquid holdup and flooding. Limitations of the empirical values are also explained by the author.

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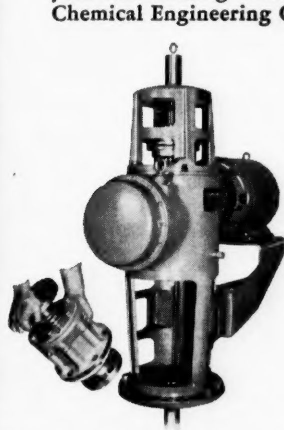

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Flow Diagram Helps Calculate x-y Curve From Boiling Points...

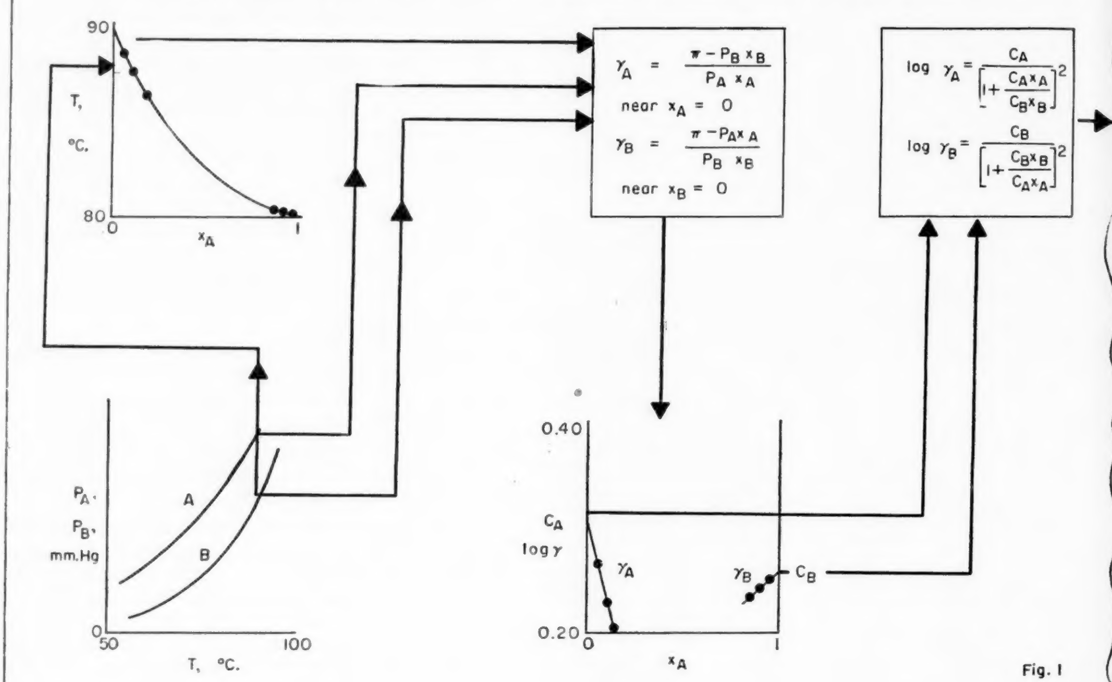


Fig. 1

How to Stretch Your Equilibrium Data—II

Can you use a new approach to vapor-liquid equilibrium measurements? Try this method based on boiling points.

JAMES O. OSBURN, State University of Iowa, Iowa City, Ia*

In last month's CE Refresher we showed how the van Laar equations are used to extend vapor-liquid equilibrium data (*Chem. Eng.*, Jan. 1957, p. 242).

This month we'll show some more uses for thermodynamics in vapor-liquid equilibrium. First, a new way of taking data. Then, a method for testing data to see if they are self consistent. And finally, we'll end this two-part section with some other equations which are sometimes better than the van Laar.

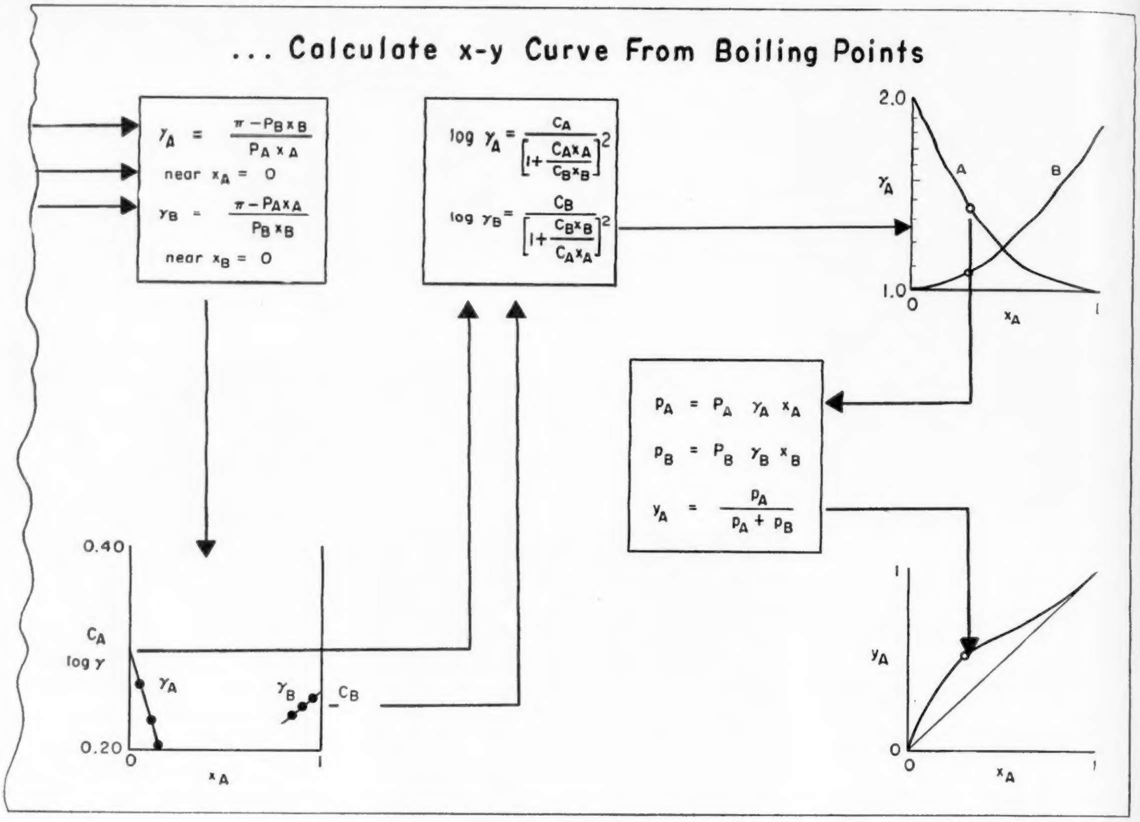
Equilibrium from Temperature Measurements

It isn't easy to get accurate x-y data. There's a serious difficulty in getting a vapor sample that is truly in equilibrium with the liquid. Another difficulty arises in measuring the vapor composition accurately.

A temperature measurement, say a boiling point, is easier to make, and is more precise than a measurement of vapor composition. Because of this, the method we are going to describe for calculating x-y data from boiling points might prove to be more convenient than measuring the x-y data directly by conventional methods.

The boiling-point method works because pure substances obey Raoult's law: that is, when x_A approaches 1.0, γ_A approaches 1.0. Let's stretch the point and assume that for mixtures of A and B that contain a large percentage of A, γ_A is equal to 1.0. When we extrapolate back to $x_A = 1.0$, this assumption becomes exact. For these solutions we find

*To meet your author see *Chem. Eng.*, Nov. 1956, p. 415.



that we can write the following set of equations:

$$p_A = \gamma_A P_A x_A \qquad (1)$$

$$p_B = \pi - p_A = \pi - \gamma_A P_A x_A \qquad (2)$$

We define γ_B by the equation

$$\gamma_B = p_B / P_B x_B \qquad (3)$$

Now we use Eq. (2) for p_B:

$$\gamma_B = \frac{\pi - \gamma_A P_A x_A}{P_B x_B} \qquad (4)$$

Since γ_A is assumed to be 1.0, for solutions that are rich in A,

$$\underset{(\text{As } x_A \rightarrow 1.0)}{\gamma_B} = \frac{\pi - P_A x_A}{P_B x_B} \qquad (5)$$

Likewise for compositions high in B, we can write this equation:

$$\underset{(\text{As } x_B \rightarrow 1.0)}{\gamma_A} = \frac{\pi - P_B x_B}{P_A x_A} \qquad (6)$$

When we know the boiling points of several mixtures, we can use Eqs. (5) and (6) to calculate the x-y curve. To illustrate this, let's take a couple of hypothetical substances A and B, for which we have vapor pressure data.

We make up several mixtures of A and B and measure the boiling points of each mixture. Then, we plot boiling point vs. liquid composition as shown on the flow diagrams above. Now we're ready to calculate the x-y diagram.

Values Calculated from Boiling Points

x_A	x_B	T	P_A	P_B
0.05	0.95	362	1,044	697
0.10	0.90	361	1,007	654
0.15	0.85	360.1	976	619
0.85	0.15	353.4	771	404
0.90	0.10	353.2	765	402
0.95	0.05	353.1	762	400

x_B	$P_B x_B$	$\pi - P_B x_B$	γ_B	$\log \gamma_B$
0.95	662	98	1.877	0.27346
0.90	589	171	1.698	0.22994
0.85	526	234	1.598	0.20358

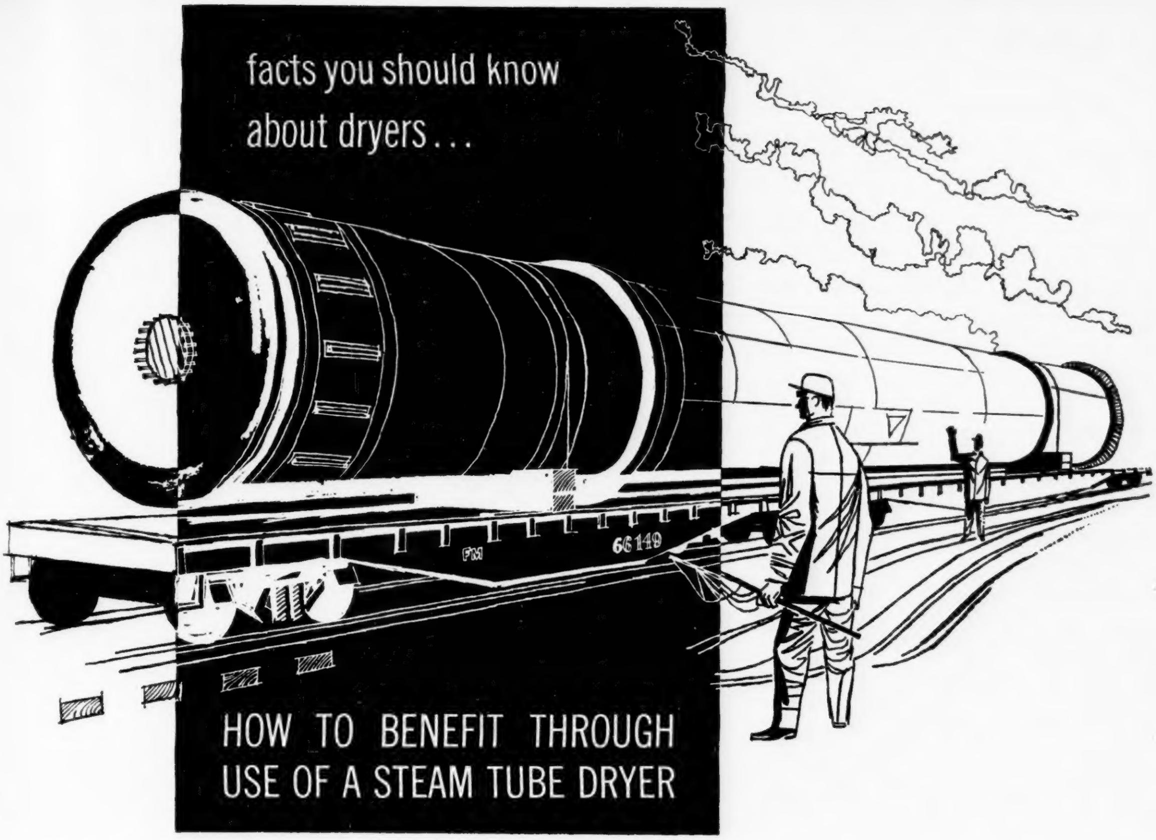
x_A	$P_A x_A$	$\pi - P_A x_A$	γ_A	$\log \gamma_A$
0.95	724	36	1.800	0.25527
0.90	689	71	1.766	0.24700
0.85	655	105	1.733	0.23880

By extrapolation: $C_A = 0.32$ and $C_B = 0.264$

These Steps Lead to the Flow Diagram

Here are the calculation steps that are shown in the composite diagrams above:

1. In the region near $x_A = 1.0$, we take values of



For over 55 years, Louisville Dryers have been solving industry's drying problems and effecting marked economies. This experience can often be applied to provide unusual benefits in specific cases, possibly yours, for example . . .

Q. *Since avoiding dust loss and contamination by furnace gases indicates the choice of an indirect heat rotary dryer for my material, what type of indirect dryer would you recommend?*

A. Unless there are abnormal conditions, *we would recommend a steam tube dryer*, especially if the material is heat sensitive.

Q. What advantages does the steam tube dryer offer *in comparison with indirect fire types?*

A. There are many advantages. One is ease of operation and low maintenance costs due to the definite moderate temperature (established by steam pressure) imposed on both the material being dried and on the dryer itself. Another advantage is that there is no furnace refractory maintenance. Still another advantage is quick "warm up" and "cool off". In many cases where the drying operation is intermittent, there is no need to shut off the steam supply or stop rotation when the wet material feed is interrupted since steam is condensed in quantity only when wet material is fed.

Q. *Isn't steam supposed to be an expensive drying medium?*

A. That depends on how the steam is used. It is true that a low overall efficiency results (often as low as 25%) when steam is used to heat air for low temperature drying. However, the Louisville Steam Tube Dryer normally utilizes 85% or more of the available heat in the steam. By combining this with a reasonable minimum efficiency of 80% in modern small steam generators (and higher in large boiler plants), you get an overall efficiency close to 70%. This compares with indirect fire dryers which develop an efficiency seldom higher than 50% and generally less.

Q. *Does material insulate the tubes by sticking to them or by clogging the spaces between tubes?*

A. Very few materials have this tendency to any serious extent and most of these, when properly conditioned before feeding, handle without difficulty. For the balance, no dryer using heated surfaces for heating the material is a proper application.

Q. *How can I be sure a Steam Tube Dryer will handle and dry my material satisfactorily?*

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Vapor-Liquid Equilibrium Calculated from Boiling Points

x_A	x_B	$\left[1+\frac{C_A x_A}{C_B x_B}\right]^2$	$\left[1+\frac{C_B x_B}{C_A x_A}\right]^2$	γ_A	γ_B	T	P_A	P_B	$P_A x_A \gamma_A$	$P_B x_B \gamma_B$	π	y_A
0.1	0.9	1.287	71.183	1.773	1.012	361	1,007	654	178.5	596	774	0.231
0.3	0.7	2.307	8.567	1.376	1.072	357.8	902	540	372	405	777	0.505
0.5	0.5	4.893	3.306	1.163	1.202	355.7	838	473	487	285	772	0.630
0.7	0.3	14.710	1.831	1.051	1.394	354.1	790	426	582	178	760	0.766
0.9	0.1	145.82	1.189	1.003	1.668	353.2	765	402	690	67	757	0.911
0	1.0	....	......	2.09	1.00	.....	.....	...	.....	...	...	.....
1.0	0	....	......	1.00	1.837	.....	.....	...	......	...	...	.....

x_A and calculate the corresponding values of γ_B by using Eq. (5).

2. For points near $x_A = 0$, we calculate γ_A by using Eq. (6).

3. Next, we plot log γ_A and log γ_B against values of x_A.

4. Then we extrapolate γ_A to $x_A = 0$; extrapolate γ_B to $x_A = 1.0$. The intercepts give the values of C_A and C_B in the van Laar equation.

$$C_A = \log \gamma_A \,;\, C_B = \log \gamma_B$$
$$(\text{As } x_A \to 0) \quad (\text{As } x_B \to 0)$$

5. Using these values of C_A and C_B, we calculate the γ-x curve as explained in last month's installment (*Chem. Eng.*, Jan. 1957, p. 242).

6. From here on, we proceed as described last month to find y for various values of x. Since we already know the boiling points, a trial-and-error solution is not necessary.

The calculations outlined in these steps are shown in the tables on the preceding page and above.

How Accurate Are Our Calculations?

The calculated total pressure in our illustrative example is about 2% high over part of the range. We could reduce this error by refining the calculation.

Instead of assuming that $\gamma_A = 1.0$ for high concentrations of A, we could use the first approximation values of C_A and C_B to calculate γ_A. Likewise, for the low-x_A region, we could calculate γ_B. Then, instead of Eqs. (5) and (6) we could use Eq. (4) with a similar equation written for γ_A.

Nomenclature (Consistent Units)

A, B	**Pure substances in equilibrium**
B, C, D, E	**Constants in the Redlich-Kister-Turnquist equations**
C_A	**Constant in the van Laar equation, limit of γ_A as x_A nears zero**
C_B	**Constant in the van Laar equation, limit of γ_B as x_B nears zero**
d	**Differential operator**
M_A, M_B	**Constants in the Margules equation**
p	**Partial pressure of**
P	**Vapor pressure of the pure substance indicated by the subscript**
T	**Absolute temperature**
x	**Mole fraction in the liquid phase**
y	**Mole fraction in the vapor phase**
γ	**Activity coefficient**
π	**Total pressure**

However, unless the deviations from ideal behavior are very great, we don't need to go through this correction process.

It Depends on the Assumptions

The accuracy of this method of calculating x-y data depends on the assumptions involved in the use of the van Laar equations. The method should be most useful for close-boiling mixtures. If you make a small error in measuring the vapor concentration of these, you have made a large error in relative volatility.

For some substances, different authors cannot even agree as to which substance is the more volatile.

By measuring the boiling points very accurately, and calculating the x-y data as described, you should be able to get data for such systems which are more reliable than you could obtain from an equilibrium still.

How Good Are Your Data?

Up to now we've been discussing ways of getting along when we don't have enough vapor-liquid equilibrium data. We face another question when we have data of questionable accuracy.

Perhaps we have found some equilibrium data in the literature; or perhaps we have taken the data ourselves and aren't sure we really had equilibrium. Is there any way we can get reassurance that the data are O.K.?

There isn't any calculation we can make to prove that our data are accurate. However, we can show that they are self consistent from the standpoint of thermodynamics. If they pass this test, our confidence in them is strengthened.

Thermodynamic Tests of Data

Starting with the Gibbs-Duhem equation, Redlich and Kister [*Ind. & Eng. Chem.*, **40**, p. 345 (1948)] derived this equation to test vapor-liquid equilibrium data:

$$\int_0^1 \log \frac{\gamma_1}{\gamma_2}\, dx = 0 \tag{7}$$

According to this equation, a plot of log (γ_1/γ_2) against x_A would have an area above the x axis equal to that below.

Also, since log (γ_1/γ_2) is equal to log γ_A minus log

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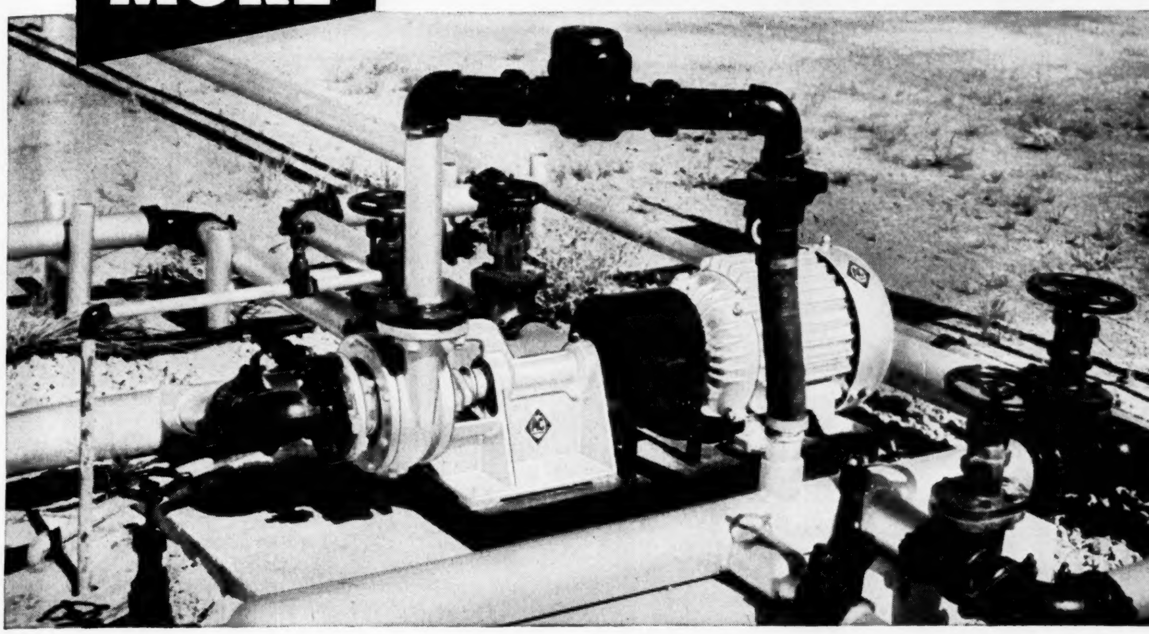

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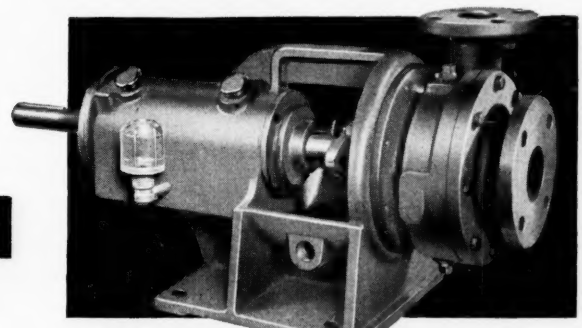

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Thermodynamics Tests Your Data

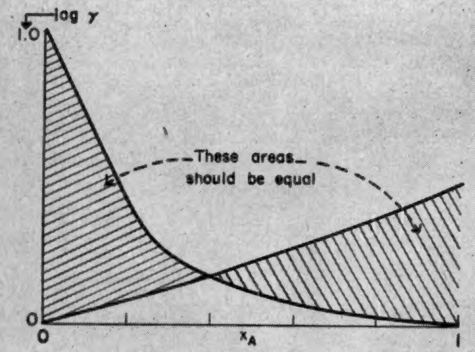


Fig. 2

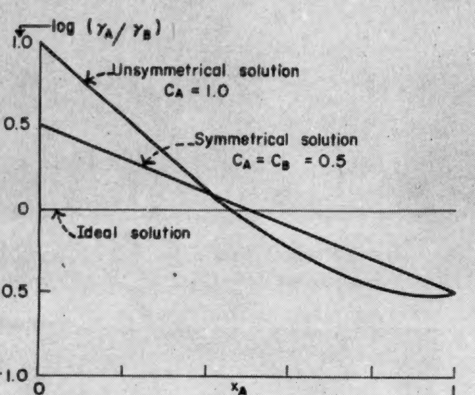


Fig. 3

γ_B, if we plot log γ_A and log γ_B against x, we find that the area between curves on one side of the intersection should equal that on the other side, as shown in Fig. 2 above.

We may get any of several different kinds of curves when we test our data in this manner. We have shown three different possibilities on Fig. 3.

First, if the mixture is ideal, both γ_A and γ_B are 1.0, and log (γ_A/γ_B) is zero for all values of x. If the substances form a symmetrical solution, so that the van Laar constants C_A and C_B are equal, then we will get a straight line. The slope of this line will be equal to $-2C_A$.

If C_A does not equal C_B, the substances are said to be "unsymmetrical" and a curved line results. The y intercept is C_A when $x_A = 0$; and C_B when $x_A = 1.0$. However, the equality of areas is still maintained.

Use These Steps to Test Your Data

Let's list the steps for testing data by the method we have just described. We have prepared a flow diagram for this calculation and it appears as Fig. 4 on the next page. Here are the steps:

1. The data will consist of x-y values and corresponding temperatures for each point. Choose a value of x and find the vapor pressures of the pure components at the equilibrium temperature.
2. Calculate γ_A and γ_B.

$$\gamma_A = y_A/P_A\,x_A \tag{8}$$
$$\gamma_B = y_B/P_B\,x_B \tag{9}$$

3. Calculate the log of (γ_A/γ_B).
4. Repeat the calculations for other points and plot log (γ_A/γ_B) vs. x_A.
5. Draw the best line which fits these points. Measure the area between the curve and the x axis which lies above that axis; and the area that lies below that axis.

If these areas are equal, the data are consistent and we have increased confidence in them. If not, something is wrong.

However, we can't tell exactly what is wrong. Maybe we didn't have true equilibrium. Or maybe the x-y data are all right, but the error was in the temperature measurement.

Some Other Equations for Equilibrium

Useful as they are, the van Laar equations cannot always be made to correspond perfectly to vapor-liquid equilibrium data. Other equations have been used to overcome some of their shortcomings on this account.

The Margules equations are very similar in form to the van Laar. The Margules equations are written in this form:

$$\log \gamma_A = (2M_B - M_A)\,x_B^2 + 2(M_A + M_B)\,x_B^3 \tag{10}$$
$$\log \gamma_B = (2\,M_A - M_B)\,x_A^2 + 2(M_B - M_A)\,x_B^3 \tag{11}$$
$$M_A = \frac{(x_B - x_A)\log \gamma_A}{x_B^2} + \frac{2\log \gamma_B}{x_A} \tag{12}$$
$$M_B = \frac{(x_A - x_B)\log \gamma_B}{x_A^2} + \frac{2\log \gamma_A}{x_B} \tag{13}$$

You can use these equations in pretty much the same way as you would use the van Laar equations. The Margules equations would give a better fit if there were a maximum or minimum in the γ—x curve.

For very unsymmetrical systems, the van Laar equations fit the data better.

Redlich, Kister and Turnquist [*Chem. Eng. Progress Symposium Series No.* 2, 48, p. 49 (1952)] derived a set of equations with more coefficients. Because of the greater number of coefficients, the equations can be made to fit the data more closely than either the van Laar or the Margules equations can.

Of course, you do more work in using them, too. These are the Redlich-Kistler-Turnquist equations:

$$\log \gamma_A = x_B^2\,[B + C(3x_A - x_B) + D(x_A - x_B)\,(5x_A - x_B) + E(x_A - x_B)^2\,(7x_A - x_B) \;\ldots] \tag{14}$$

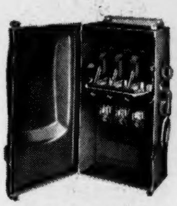
$$\log \frac{\gamma_A}{\gamma_B} = [B(-x_A + x_B) + C(6\,x_A\,x_B - 1) + D(x_A - x_B)\,(8x_A\,x_B - 1) + E(x_A - x_B)^2\,(10x_A\,x_B - 1) + \;\ldots] \tag{15}$$

For a solution that is nearly perfect, C, D and E

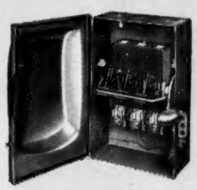
FIRST with a COMPLETE LINE OF SAFETY SWITCHES to meet the NEW NEMA STANDARDS

• The table below shows Square D switches meeting new industry specifications. Notice how they clarify conflicting features which existed under old designations. Notice, too, that they establish a new, heavy-duty industrial switch, Type HD.

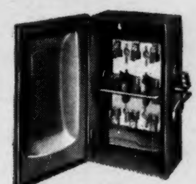
One important thing which remains unchanged is the **DESIGN LEADERSHIP** which has made **SQUARE D SAFETY SWITCHES** an overwhelming **FIRST** choice in the petroleum and chemical industries for more than fifty years.



TYPE HD*



TYPE ND



TYPE LD

***Available in NEMA 12, NEMA 4, 5, 7 and 9 Enclosures**

DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

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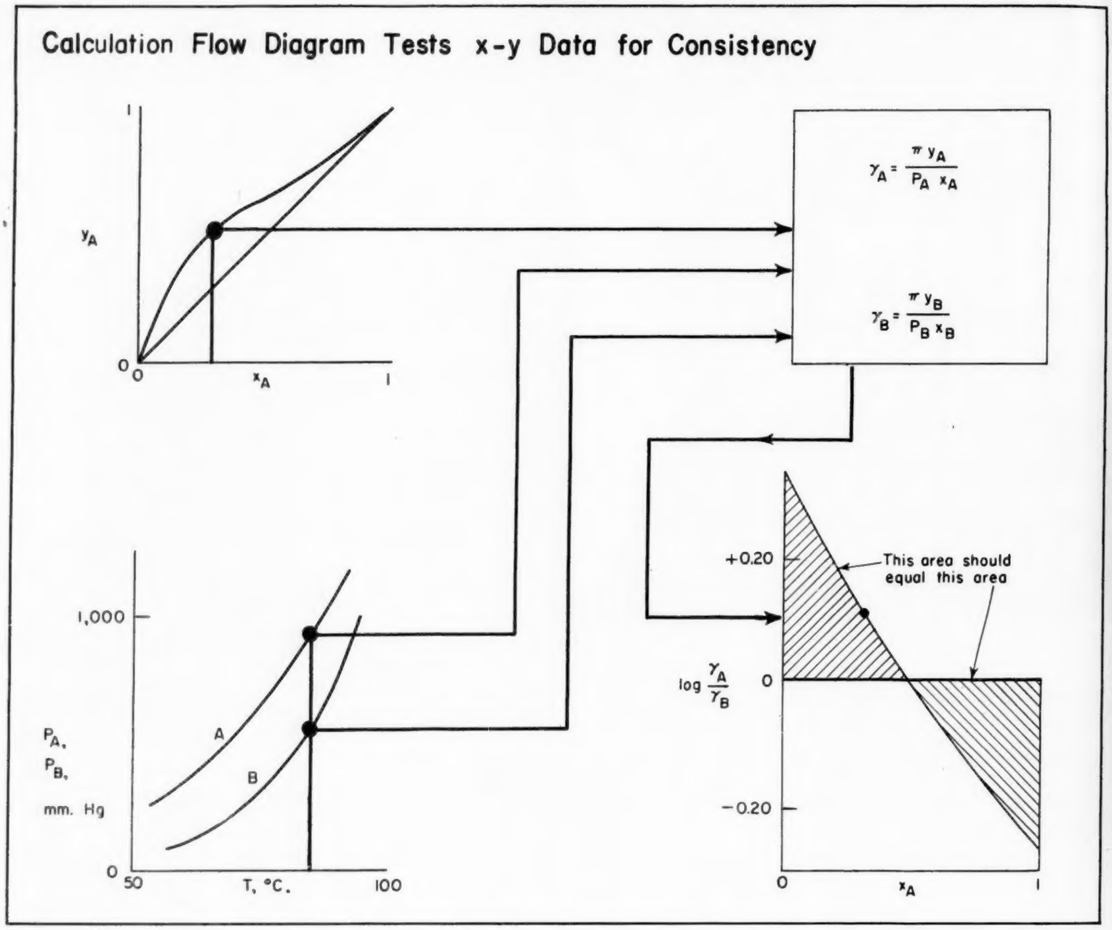

are all zero. For those which deviate somewhat more, *C* will have a value, and so on.

For extremely imperfect mixtures, all four coefficients are needed.

Next Month: Three-Component Equilibrium

So far we have limited our discussion to two components. Much of the time the mixtures you have to process contain three or more substances that contribute to equilibrium.

Next month, we're going to take up some of the problems which arise from the presence of extra components, in a new series on three-component vapor-liquid equilibrium.

After three-component vapor-liquid equilibrium we'll turn our attention to liquid-liquid equilibrium emphasizing design for three or more components.

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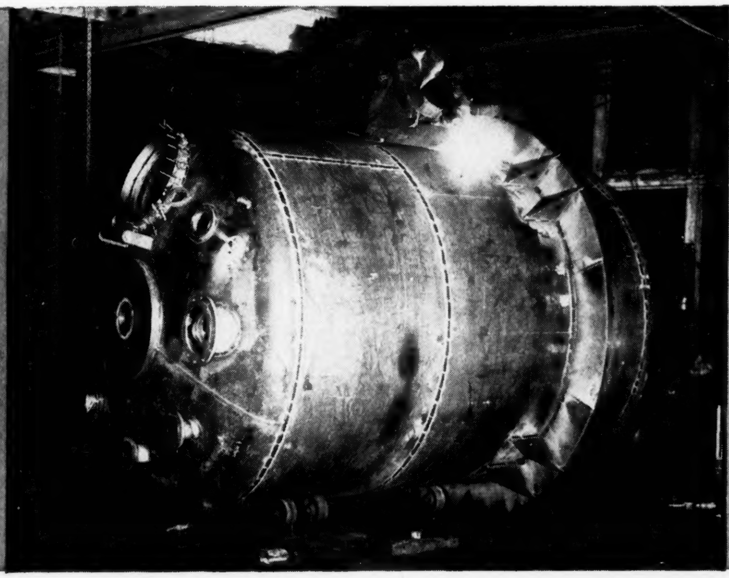
reduces delivery time by one year

–New Jersey fabricator uses
CF&I NICKEL PLATED STEEL PLATES
for caustic evaporator



A welder at the L. Lawrence Company puts the finishing touches on an 8-foot diameter caustic evaporator. Heads and plates are all fabricated from CF&I Lectro-Clad, nickel plated on all inside surfaces for protection against contamination. Rolling, shearing and severe forming of Lectro-Clad are easily accomplished, using normal steel fabricating methods—the nickel plating *will not* check, spall or flake.

■ Instead of waiting a year for hard-to-get, expensive nickel, the L. Lawrence Company, Inc., of Newark, New Jersey used ⅜-inch steel plates with a .015-inch, Lectro-Clad nickel plating in making a caustic evaporator for a large chemical company. Results—a completely successful evaporator . . . *at lower cost . . . delivered a year sooner than expected . . . fabricated with standard procedures.*

The Lectro-Clad nickel plating on the inside surface of the evaporator does the same job as solid nickel or nickel-clad steel in protecting against discoloration and contamination . . . the carbon steel plates give structural strength and durability. What's more, you can expect plate delivery in six weeks when you order CF&I Lectro-Clad.

If you use, or fabricate, heavy industrial equipment where product contamination is a problem, you can probably use CF&I Lectro-Clad to good advantage. For further details, write for the Lectro-Clad Technical Manual, Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation, P. O. Box 1951, Wilmington, Delaware. 4372

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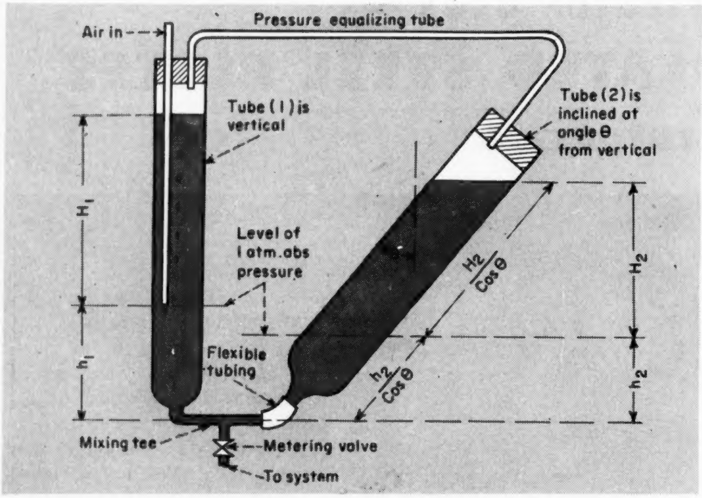

Nomenclature

- A_1 Area of Tube (1) above area of air-bleed tube (annual area).
- A_2 Area of Tube (2) perpendicular to axis.
- h_1 Height of liquid in Tube (1) between mixing tee and point of 1 atm. abs. pressure.
- H_1 Height of liquid above point of 1 atm. abs. pressure.
- h_2 Height of liquid in Tube (2) between mixing tee and point of 1 atm. abs. pressure.
- H_2 Height of liquid above point of 1 atm. abs. pressure.
- ρ_1 Density of liquid in Tube (1).
- ρ_2 Density of liquid in Tube (2).
- θ Angle of inclination of Tube (2) to vertical.

★ **Winner of November Contest**

Ratio Feeder Gives Constant Delivery

Constant head feeder for pilot plant or lab can be made of pipe or glass, will accurately ratio two or more liquids.

G. A. Lessells
Development Dept., Hydrocarbon Chemical Div., Olin Mathieson Chemical Corp., Bradenburg, Ky.

Quite often the pilot plant engineer or researcher will be confronted with the necessity of feeding two liquids at a constant ratio and very low flow rates to a homogenous reaction system. Rotameters are generally used, but these are difficult to control when in the range of say, 1 ml./min. of total flow. Controlled volume pumps may be the answer, if available, but their cost is usually high, and materials of construction may be a problem.

A device which I have found useful can be made of either glass tubing or pipe, and can be readily set up to give constant-ratio metering using only one flow meter. Variations in total flow will not affect the ratio of the two feed streams. The sketch above is a diagram of this feed system which it will be noted also uses a commonly known technique for maintaining constant head on the system.

There is one vertical tube, and one tube which can be tipped through a range of angles from the vertical by use of a piece of flexible rubber or plastic tubing. If corrosion is a problem, Pyrex glass pipe joints or ball-and-socket glass fittings may be used. The two tubes are filled, each with one of the two liquids to be fed, to heights which are inversely proportional to their densities. The heads exerted in each tube will then be equal, and there will be no tendency for one liquid to rise in the other tube.

After filling the tubes are stoppered, then joined together by a section of tubing to equalize pressure in the air space. Tube (1) is provided with an air inlet tube extending below the liquid

---

★ **Winner of December Contest—Harlan How**

"Use an Orifice to Control Heat Transfer."

How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 cash each month to the author of the best short article received that month and accepted for the Plant Notebook.

Each month's winner will be announced in the issue of the second following month, and published the third following month.

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Articles may deal with plant or production "kinks," or novel means of presenting useful data, of interest to chemical engineers. Address Plant Notebook Editor, *Chemical Engineering*, 330 West 42nd St., New York 36, N. Y.

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surface. The liquids flow from the bottom of the tubes and meet in a narrow-bore mixing tee if the liquids are fairly close in densities. Liquids with widely differing densities may require better physical mixing such as in a small aspirator or a venturi.

After mixing in the tee or other mixing device, the liquids pass on to be metered by some device such as a rotameter, orifice or calibrated metering valve. As air bleeds into Tube (1) and equalizes the air-space pressure in Tube (2), the liquids flow out under influence of the constant head of liquid from the mixing tee up to the lower end of the air bleed tube. This, of course, is always at 1 atm. abs. pressure. And the liquids flow out at a constant ratio, always maintaining total heights above the mixing tee in inverse proportion to the liquid densities. The adjustment in ratios is possible by varying the angle θ of Tube (2), which varies the length and hence the volume of the fluid in Tube (2) accordingly.

The volumes of liquid in Tubes (1) and (2) above the point of 1 atm. abs. pressure are given by the expressions:

$$V_1 = A_1 H_1 \qquad (1)$$

$$V_2 = A_2 H_2/\cos\theta \qquad (2)$$

The heads exerted by each column of liquid, H_1 and H_2, are equal since they are at atmospheric pressure at the lower ends of the columns. Therefore the following is true: $H_1\rho_1 = H_2\rho_2$ and $H_1 = H_2(\rho_2/\rho_1)$. If we then divide V_1 by V_2 we get: $V_1/V_2 = A_1H_1 \cos\theta/A_2H_2$. Then, replacing H_1 by $H_2(\rho_2/\rho_1)$ gives: $V_1/V_2 = A_1\rho_2 \cos\theta/A_2\rho_1$, and solving for $\cos\theta$ we get

$$\cos\theta = \frac{V_1\,\rho_1\,A_2}{V_2\,\rho_2\,A_1} \qquad (3)$$

We now have an expression for $\cos\theta$, and knowing the densities of the two fluids, the volumetric ratio desired, and the areas of the tubes, we can calculate the correct angle at which to set Tube (2).

As an example, suppose we wish to react an organic liquid of density 0.9 grams/ml. with an aqueous inorganic solution of density 1.2 grams/ml. in a mole ratio of 4:1, organic to inorganic. The molecular weight of the organic is 45, and the concentration of the inorganic is 2.4 moles/liter. If we have available some glass tubing with an annular area of 4 sq. cm. with a glass air-bleed tube inserted, and another tube of 10 sq. cm. cross-sectional area, at what angle should we incline the larger tube from the vertical? We will arbitrarily place the organic liquid in Tube (1).

Since we are interested in the ratio of feeds, not the amount, let us take as a basis 4 moles of organic liquid and 1 mole of inorganic. Then, 4 moles organic = $(4 \times 45)/0.9 = 200$ ml. $= V_1$; and 1 mole inorganic $= 1{,}000/2.4 = 417$ ml. $= V_2$.

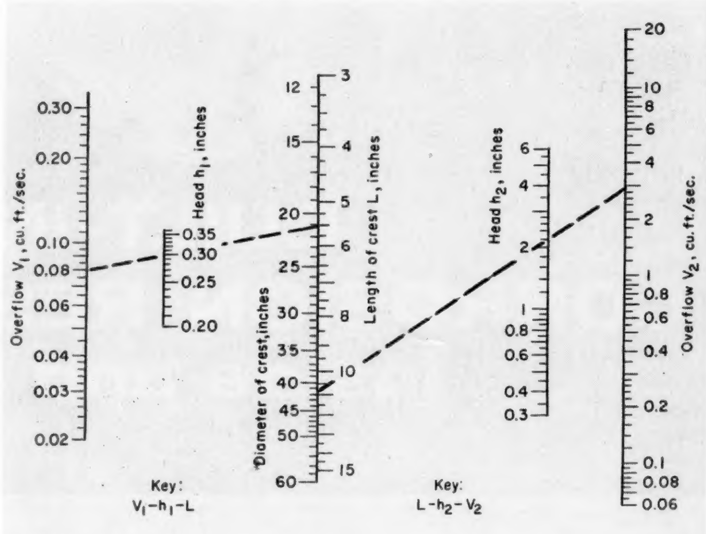
Then, substituting in Eq. (3):

$$\cos\theta = \frac{V_1\,\rho_1\,A_2}{V_2\,\rho_2\,A_1}$$

$$= \frac{200 \times 0.9 \times 10}{417 \times 1.2 \times 4} = 0.90$$

and $\theta = 26°$ from vertical.

This system is obviously adaptable to feeding more than two liquids. A similar derivation can be made for three or more components in an analogous manner. Materials are not limited to glass, either. If the liquids handled are corrosive to glass, metal pipes may be used. In this case a valve is necessary in the liquid line between tubes. This would be closed during charging since no visual check could be made of the relative heights in the tubes. After being sure that the column heights are correct, and hence the heads are balanced, this valve can be opened.



Peripheral Overflow From Tanks

D. S. Davis
Professor of Engineering, University of Alabama, Tuscaloosa, Ala.

In designing thickening tanks, one is faced with the problem of calculating rates of overflow at the perimeter where heads are extremely low. For water and dilute solutions, the following equations are recommended by Kammermeyer (*Ind. Eng. Chem.*, **36**, 202, 1944):

$$V_1/L = H_1 - 0.0105$$
(for $H_1 < 0.03$ ft.)

and

$$V_2/L = 3.2\, H_2^{1.455}$$
(for H_2 from 0.03 to 1 ft.)

Here V_1 and V_2 are rates of overflow, cu. ft./sec.; L is perimeter of crest, ft.; and H_1 and H_2 are heads, ft.

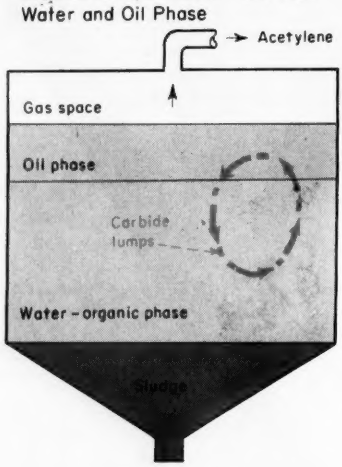
(*Please turn page.*)

These equations can be solved quickly and accurately by means of the accompanying nomograph, which was constructed by standard methods.

Use of the chart, which is really two nomographs that share the L-scale, is illustrated as follows: What is the rate of overflow of water from the perimeter of a tank that is 21 in. in diameter when the head is 0.30 in.? Connect 21 on the diameter scale (where $L = 5.5$ ft.) and 0.30 in. (0.025 ft.) on the h_1-scale with a straight line. Continue this line to the V_1-scale at the left and read the desired value as 0.08 cu. ft./sec. (36 gpm., where cu. ft./sec. $\times$ 448.5 = gpm.).

What is the rate of overflow of water from the perimeter of a tank that is 42 in. in diameter when the head is 2.2 in.? Connect 42 on the diameter scale (where $L = 11$ ft.) and 2.2 in. (0.18 ft.) on the h_2-scale with a straight line. Project this line to the V_2-scale at the right and read the desired value as 2.9 cu. ft./sec.

Carbide Lumps "Teeter" Between Water and Oil Phase



Sink-Float Process Aids Acetylene Generation

Frank Gibadlo
Process Chemical Specialties
Beverley, Mass.

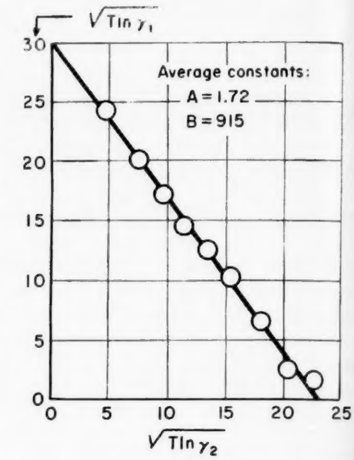
Some time ago I developed a novel process for generating acetylene from calcium carbide. This process has some advantages over the ordinary methods, notably in faster and more uniform generation of the gas, with roughly a 10% increase in the amount of carbide that will react with the same volume of water.

The secret lies in the addition of small quantities of organic chemicals to the water, so that the acetylene bubbles attach themselves to the carbide lumps and carry them up into a nonaqueous phase where the reaction is stopped. After the bubbles escape up to the surface, the carbide particles sink again into the water phase where the process is repeated.

The organic added to the water may be cyclohexanol or aniline, or a mixture of the two. This is mixed with an alcohol to improve solubility and reactivity. I found the best combination to be a mixture of 50% each by volume of cyclohexanol and isopropyl alcohol. This is then added to the extent of 0.05 to 0.5% by volume to the water used to react with the carbide. Usually, a 0.1-0.3% mixture of the mixed organics in water gives good results.

The sketch shows how the method is applied. A closed, conical-bottom tank is filled part way with water containing the mixed organics, and the water layer is then topped with a light hydrocarbon such as range oil, No. 1 fuel oil, or naphtha. When calcium carbide lumps (about $\frac{1}{3}$ in.) are added to the two phases, they sink through the oil phase and, on reaching the water phase, start to react to form acetylene. The bubbles then buoy up the lumps which rise into the oil phase. Here the reaction stops, the bubbles escape to the gas space above, and the lumps again settle into the water phase.

Sludge sinks to the bottom, away from the reaction, permitting complete utilization of the carbide. The oil layer helps to prevent the carbide from overheating and also acts as a blanket or seal during cleaning, or if too much carbide is put into the generator. Incidently, addition of a trace of sulphuric acid will eliminate any persistant foaming.



Simple Method Evaluates Van Laar Constants

Robert A. Snedeker
Photo Products Dept.
E. I. du Pont de Nemours & Co.
Parlin, N. J.

Here is a convenient and precise method for evaluating the constants in the Van Laar equations for correlating vapor-liquid equilibrium data in binary systems:

$$\ln \gamma_1 = \frac{B/T}{[1 + A(x_1/x_2)]^2} \quad (1)$$

$$\ln \gamma_2 = \frac{AB/T}{[A + (x_2/x_1)]^2} \quad (2)$$

Rearrange and eliminate x_1/x_2 between the equations:

$$\sqrt{T \ln \gamma_1} = \sqrt{B} - \sqrt{A}\,\sqrt{T \ln \gamma_2} \quad (3)$$

The data can be plotted as $(T\ln\gamma_1)^{1/2}$ versus $(T\ln\gamma_2)^{1/2}$ and the constants, A and B, evaluated from the intercepts.

The best straight line through the data can be calculated by regression, and confidence limits can be placed on the values of A and B obtained. This regression analysis is more appropriate to this method of evaluation because the points to be plotted have more nearly the same error associated with each point than is true in the still-popular method suggested by Robinson and Gilliland.[1, 2]

A typical plot appears above.

REFERENCES

1. Robinson, C. S., and E. R. Gilliland, "Elements of Fractional Distillation," pp. 60, 65-72, McGraw-Hill Book Co., Inc., New York (1950).
2. Weber, J. H., *Ind. Eng. Chem.*, **48**, 134-136 (1956).

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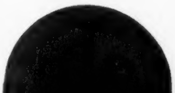

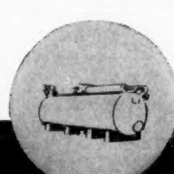

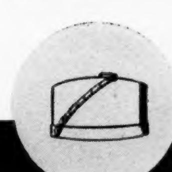

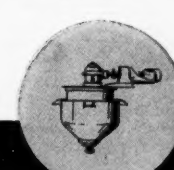

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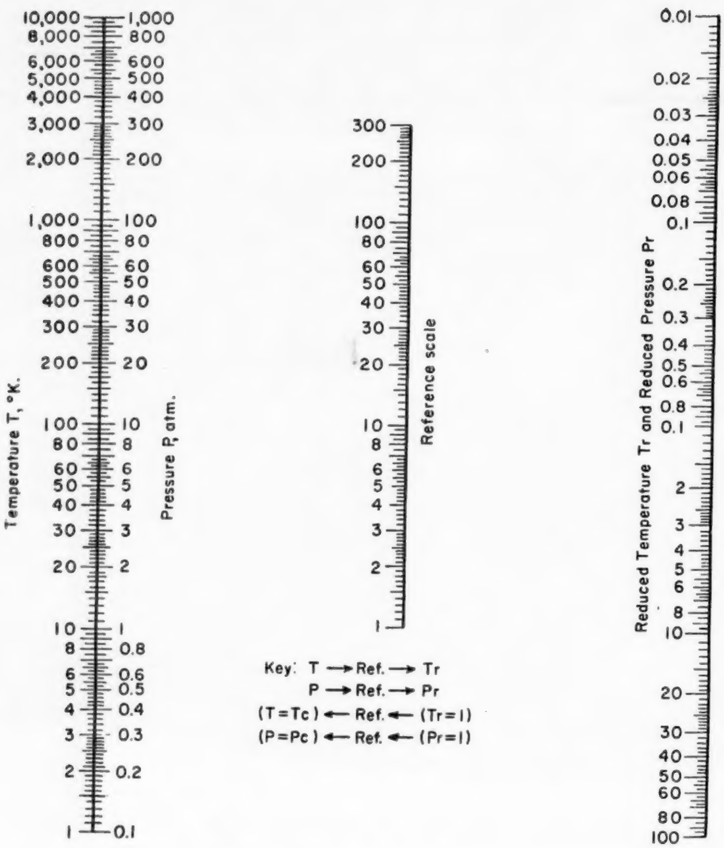


Chart for Reduced Temperature, Pressure

Liang-tseng Fan
Dept. of Chemical Engineering, W. Va. University, Morgantown, W. Va.

In determinations involving the properties of gases, the calculations of the reduced temperature Tr and pressure Pr are rather simple; however, the use of the accompanying nomograph is time saving, especially when the calculations must be done repeatedly and frequently. In addition, the values of the critical properties may be obtained directly from this nomograph.

Operating points on the reference scale for various gases are listed in the accompanying table in alphabetical order.

The operating points of any other gases, not listed in the table, may be located on the same reference scale by a user of this nomograph if he knows their critical properties.

Example 1—Find the reduced temperature Tr and reduced pressure Pr of benzene at 800 K. and 20 atm. From $T = 800$ through Ref. = 23.5 to $Tr = 1.42$; from $P = 20$ atm. through Ref. = 21.9 to $Pr = 0.42$.

Example 2—Find critical temperature and pressure of methane. From $Tr = 1.0$ through Ref. = 13.9 to $Tc = 191$ K.; from $Pr = 1.0$ through Ref. = 21.8 to $Pc = 46$ atm.

Operating Points for Use on Reference Scale

Substance	Reduced Temperature, Tr	Reduced Pressure, Pr	Substance	Reduced Temperature, Tr	Reduced Pressure, Pr
Acetylene	17.6	25.0	Ethane	18.3	21.9
Air	11.5	18.5	Ethyl chloride	21.3	22.3
Ammonia	20.2	33.5	Ethylene	16.8	22.1
Argon	12.4	21.8	Fluorine	37.3	23.2
Benzene	23.5	21.9	Helium	2.21	4.7
Boron trifluoride	16	22	*n*-Heptane	23.2	16.2
n-Butane	20.8	19	*n*-Hexane	22.6	17.1
Carbon dioxide	17.5	27	Hydrocyanic acid	21.2	23.6
Carbon monoxide	11.5	18.9	Hydrogen	5.7	11.2
Carbon oxysulfide	19.3	24.4	Hydrogen bromide	19	9
Chlorine	20.3	27.4	Hydrogen chloride	18.1	28.3
Cyanogen	20.1	24.1	Hydrogen iodide	20.8	28.5
Cyclohexane	23.3	20	Hydrogen sulfide	19.3	29.7
Dichlorodifluoro methane	19.7	19.9	Isobutane	20.2	19.8
Dichloro methane	21.9	22.8	Isopentane	21.4	18.2
Diethyl amine	22.1	19.1	Krypton	14.3	23.5
Diisobutyl	23.2	15.5	Mercury	33.8	42
Diisopropyl	22.2	18.3	Methane	13.9	21.8
Dimethyl amine	21	22.5	Methyl chloride	20.2	25.5

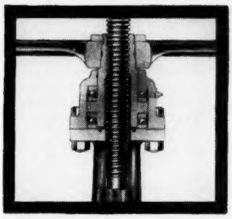
Dry Ice Expels Vapors Prior to Welding

Paul C. Ziemke
Engineer, Oak Ridge, Tenn.

Work on a sewer line adjacent to a blow case containing ether caused rupture of a seam in the case. In casting about for a quick, inexpensive way to eliminate the ether fumes, the mechanic came up with a method which would do the job and make certain of safety during the operations of grinding off the old weld bead, and rewelding the seam.

He broke up about 4 lb. of dry ice into pieces small enough to enter the opening of the 2-in. flange. After 20 min. the CO_2 gas generated as the dry ice vaporized had completely filled the defective tank and expelled the oxygen. It had also condensed any of the vapors that remained in the tank.

The grinding and welding then proceeded with dispatch and without danger of explosion. Hydraulic testing followed and the tank was put back into service without any need for removal to the shop.



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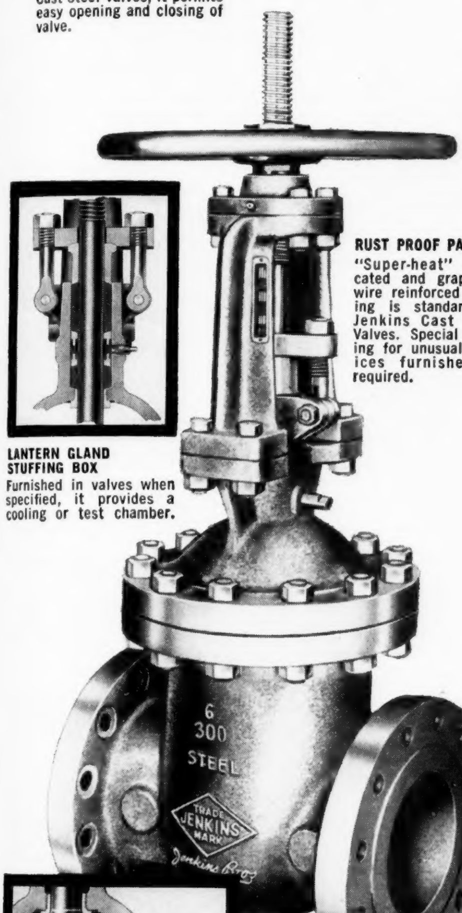

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Furnished in valves when specified, it provides a cooling or test chamber.

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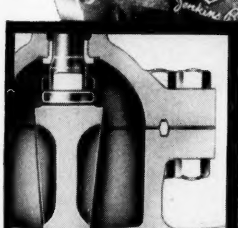
"Super-heat" lubricated and graphited, wire reinforced packing is standard for Jenkins Cast Steel Valves. Special packing for unusual services furnished as required.



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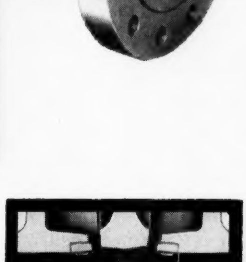

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JENKINS CAST STEEL VALVES

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Compare every feature, and you'll see why Jenkins Cast Steel Valves are first choice for so many systems planned for lowest operating cost.

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PRESSURES	150 lb. — 300 lb. — 400 lb. — 600 lb.
PRESSURE CASTING ALLOYS	Carbon Steel — 150 lb. Valves Carbon Molybdenum Steel — 300, 400, 600 lb. Valves Chromium Molybdenum Steel (when ordered)
SEATING METALS (in various combinations)	H Monel 13% Chromium Stainless Steel Carbon Molybdenum Steel, Stellite faced AISI Type 316 Stainless Steel

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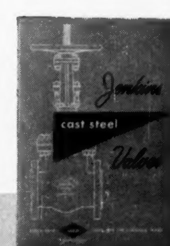

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CE Flow File—II

Maxey Brooke, Chemical Engineer, Old Ocean, Texas

(For author biography see *Chem. Eng.*, Jan. 1957, p. 298.)

4. Water

APPLICATION

Flow of water in open channels.

FORMULAS

$$V = C\sqrt{rs} \qquad C = \frac{87}{0.552 + m/\sqrt{r}}$$

REFERENCE

Bazin, Annales des ponts et chaussées, 1897 4e trimestre, pp 20–70

NOMENCLATURE

V = Velocity, fps.
r = Hydraulic radius, ft.
s = Loss of head, ft. of water per ft. of channel.
m =
- 0.06 for smooth cement or matched boards.
- 0.16 for planks and bricks.
- 0.46 for masonry.
- 0.85 for regular earth beds.
- 1.30 for canals in good order.
- 1.75 for canals in very bad order.

---

5. Water

APPLICATION

Water flow from a vertical open end pipe.

FORMULA

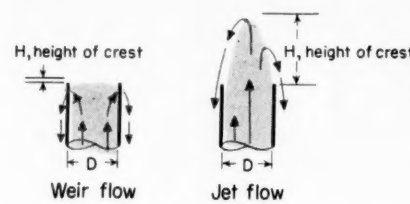
$V = 8.80\ D^{1.29}\ H^{1.34}$ for weir flow
$V = 5.84\ D^{2.025}\ H^{0.53}$ for jet flow.

NOMENCLATURE

V = Flow, cfs.
D = Internal pipe diameter, ft.
H = Distance from pipe outlet to top of crest, ft.

REFERENCE

Lawrence and Braunworth, *Trans. Am. Soc. Civil Engrs.* 57, p. 209



TRANSITION FROM WEIR TO JET FLOW

Pipe Diameter, In.	Head, Ft. at Transition From	To
2	0.04	0.20
4	0.15	0.40
6	0.15	0.50
8	0.30	0.75
12	0.40	1.00
18	0.75	1.00
24	1.00	3.00

---

6. Water

APPLICATION

Flow of water through round wood stave pipe.

EQUATION

$$H_f = 0.00042\ L\ \frac{V^{1.80}}{d^{1.17}}$$

LIMITATIONS

4 to 12 in. diameter pipe.

NOMENCLATURE

H_f = Pressure drop, ft. of water.
L = Length of pipe, ft.
d = Diameter of pipe, ft.
V = Velocity, fps.

REFERENCE

Fred C. Scobey, Dept. of Agriculture Bull. 376 (1916, revised 1926)

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7. Water

APPLICATION

Flow of water through concrete pipes.

FORMULA

$$H_f = \frac{V^2}{C^2\ d^{1.25}}$$

LIMITATIONS

Use for pipes with 8 to 63½ in. diameters.

REFERENCE

Fred C. Scobey, *U.S. Dept. of Agriculture Bull.* 852

NOMENCLATURE

H_f = Pressure drop per 1,000 ft. of pipe, ft. of water
V = Velocity, fps.
C =
- 0.267 for pipes laid without removal of mortar squeeze.
- 0.310 for dry mix pipes, monolithic pipes or tunnel linings made over rough wood frames and cement gun surfaces.
- 0.345 for monolithic pipes laid over steel forms.
- 0.374 for glazed interior pipes.

d = Internal diameter of pipe, in.

PRACTICE ...

CORROSION FORUM EDITED BY R. B. NORDEN

Problem I
Steel elbows and pipe restrictions corroded rapidly in cold concentrated H_2SO_4—straight sections had little corrosion.

High velocities of liquid stream had been removing protective layer of ferrous sulfate.

Solution
Stream velocity was cut down from about 4 ft./ sec. to a safe 2 ft./ sec. by increasing pipe size.

Problem II
High alloy steel valves proved to be unsatisfactory for handling 45% sulfuric acid containing suspended carbon.

Carbon set up electric circuits, and galvanic corrosion took its toll of the nickel-alloy steel.

Solution
A newly designed Duriron valve proved to be unaffected by galvanic corrosion.

Problem III
Copper tubes of a surface condenser handling 5% sulfuric acid vapors showed signs of corrosion after six months.

Most of the "corrosion" was due to erosion—acidic vapors impinging on the inside of the tubes.

Solution
Erosion was materially reduced by substituting a hard aluminum-bronze alloy (Ampco 8).

Problem IV
Copper piping failed when handling hot hydrocarbon vapors, supposedly containing sulfuric acid mist.

Analysis showed very little H_2SO_4 in the stream—instead there was 9% concentration of SO_2.

Solution
Type 316 stainless steel was substituted for copper. It has good corrosion resistance against SO_2.

Solving Unexpected Corrosion Problems

G. D. Gardner, National Petro-Chemicals Corp., Tuscola, Ill.*

There have been a number of unexpected corrosion problems at National Petro-Chemicals' plant† at Tuscola, Ill., although hydrocarbon feed stocks and all end-products are non-corrosive. Most of the problems developed because of acids (sulfuric and hydrochloric) necessary for carrying out chemical reactions. Some of the most serious situations developed in the units producing ethyl alcohol.

At Tuscola, 98% sulfuric acid reacts with ethylene. The sulfate products are hydrolized with water. In stripping collums, acid is separated from the alcohol and leaves the strippers boiling at 45%, carrying finely divided carbon in suspension. After most of the carbon is removed from the acid, it is concentrated under vacuum to 77% or 92% as conditions warrant. This "intermediate" acid then goes to an adjacent USI plant for sale or concentration to 98% with SO_3.

Unexpected corrosion was first encountered when carbon steel piping carrying cold concentrated sulfuric acid plugged up with sodium salts and it became necessary to "melt" the mixture with steam. Also copper piping corroded rapidly when sulfur dioxide built up in a recycle stream. And high alloy valves failed by galvanic corrosion (concentrated acid carrying carbon in suspension) when connected to carbon and lead-lined equipment.

It was recognized early in the design stages that many corrosive materials would be handled in the synthesis of the end products from petroleum gases. Choice of construction materials was based on the best information available. When published information was inadequate, special laboratory and pilot plant tests were made. As a result of this planning, the toll of corrosion has not been unusually severe, although sulfuric acid and hydrochloric acid are handled at many temperature levels through all concentration ranges with many contaminants present. Most of the problems encountered have been due to these contaminants or to a wider fluctuation in concentration or velocity than anticipated.

Materials of construction include steel, tantalum, Hastelloys B, C and D, Durimet 20 and Carpenter 20, Duriron, lead, silver, copper, Monel, various bronzes, and various stainless steels.

In addition, non-metals such as polyethylene, Teflon, Haveg, carbon, polyvinyl chloride and Fiberglas-reinforced polyester have found application. Each has given good service, although some failures have occured.

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* Meet your author on page 323.

† National Petro-Chemicals, jointly owned by National Distillers Products Corp. and Panhandle Eastern Pipeline Corp., produces ethylene, polyethylene, ethyl alcohol, ether and ethyl chloride at Tuscola. U. S. Industrial Chemicals Co., a Division of National Distillers Products Corp., makes sulfuric acid, ammonia, nitrates and phosphoric acid in an adjacent plant.

Composition of Some Materials Used at Tuscola—Table I

Alloy	% Cr	% Ni	%Mo	% Cu	% Mn	% Si	% C	% Fe	% V	% Pb	% Al
Stainless 316	19.0	10.0	2.25	.....	0.60	0.85	0.04	Bal.	....	.....	.....
Aloyco 20	19.5	29.0	2.25	3.75	0.60	0.85	0.04	Bal.	....	.....	.....
Aloyco 35	25.0	20.0	3.00	2.75	0.60	0.85	0.04	Bal.	....	.....	.....
Hastelloy B (Aloyco N-2)	.....	Bal.	28.0	.....	1.00	1.00	0.10	6.00	0.40	.....	.....
Hastelloy D	.....	Bal.	.....	3.00	.....	10.00	.....	...	....	.....	1.5
Chemical lead	.....	.....	.....	.....	.....	.....	.....	.....	....	99.9	.....
Inco 803	21.0	39.0	3.0	1.75	0.75	0.40	0.08	Bal.	(0.45 Ti.)	.....	.....
Ampo 8*	.....	.....	.....	Bal.	.....	.....	.....	1–3	....	.....	6–8
10*	.....	.....	.....	Bal.	.....	.....	.....	2.25–3.25	....	.....	8–9.5
12*	.....	.....	.....	Bal.	.....	.....	.....	2.25–3.25	....	.....	10–12
Carpenter 20*	18–22	21–31	.....	.....	.....	.....	0.07	Bal.	....	.....	.....
Nionel*	21	40	3	1.75	.....	.....	.....	31	....	.....	.....

*Approximate compositions

Case I—Unexpected Corrosion From H_2SO_4

Sulfuric acid is commonly carried in steel equipment when below 100 F. at concentrations between 70% and 100%. Published figures show the penetration rate to vary between 0.005 and 0.05 ipy. for this range.

This low rate is possible because ferrous sulfate, the primary corrosion product under these conditions, is insoluble in the cold concentrated acid and forms a protective layer on steel. At higher temperatures or lower concentrations, the ferrous sulfate is soluble in the acid and at velocities greater than two or three ft./sec. the protective layer is washed away.

Because of this resistance, equipment and piping components handling cold intermediate acids (77% and 92%) and the feed acid (98%) were made of regular carbon steel.

During early operation of the alcohol plant, sodium sulfite and sodium sulfate built up in these recycled acids to such an extent that the freezing point of the mixture was above the temperature of the steam traced lines in cold weather.

▶ **Removing Ferrous Sulfate**—To unplug these transfer lines, we had to inject steam at drain and vent connections. The resulting localized high temperature, lower concentration and high velocity rapidly eroded the protective ferrous sulfate layer and corroded the steel opposite the points of entry of the steam. As the acid partially "thawed" out, a dilute hot acid stream started flowing over the "unmelted" heavier layer. This rapidly thinned 90° elbows and the top of some straight sections of pipe where there was a slight dip between supports.

Changes in process equipment have eliminated this build-up of soluble salts and the required thawing operation. Failures still periodically occur but at much longer intervals. These are usually at sections thinned during this first period of operation. Other points of failure have been at 90° elbows or sections where restrictions or dips in the line result in locally higher velocities than two ft./sec.

During one period of operation, the rate of failure was unusually high. It was then found that the acid was transferred at rates exceeding four ft./sec. for short periods to permit longer periods for pump and equipment maintenance. When transfer was made on a relatively continuous basis at lower rates, the incidence of failure dropped noticeably. Where higher rates have been necessary, we've found it economical to increase piping size to reduce velocity. At concentrations higher than 92%, Carpenter 20 has proved worthwhile for handling cold acids where pipe size could not be increased.

Case II—Unusual Corrosion From Weak H_2SO_4

The boiling "weak acid" (45%), containing some dissolved hydrocarbon gas and finely divided carbon in suspension, is one of the most corrosive liquids handled. Carbon and lead-lined equipment are normally used for this service. But valves, special reducers and similar fittings are not readily made with carbon and lead-lining and so equipment for these items were made of specially-resistant alloys.

Duriron lubricated plug valves, which combine the known good resistance of Duriron with the minimum flow resistance of a plug valve were first used around pumps handling boiling 45% H_2SO_4. All lubricants that were tried "washed" out very rapidly. Valve plugs, when forced, would seize with breakage of the brittle Duriron parts. Before finally resorting to a new patterned Duriron "Y" valve—which has proved very satisfactory—several different types of acid-resistant materials, were tried out.

Because of the difficulty with lubricant in the plug valves and piping limitations, gate valves were considered as the best type.

▶ **Corrosion Testing**—Corrosion tests were made using samples of materials in which gate valves were then available. Weighed test specimens, mounted on special holders furnished by Alloy Steel Products Co., were installed in the piping where conditions most nearly approached those at the valves where failures had occurred.

After the samples had been in the system for 900 hr., the specimens were removed, cleaned and reweighed. As shown in Table II, none of the materials

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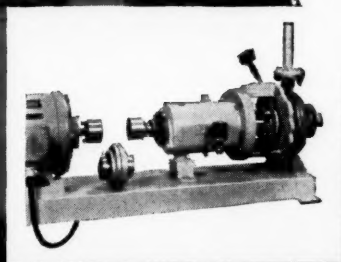
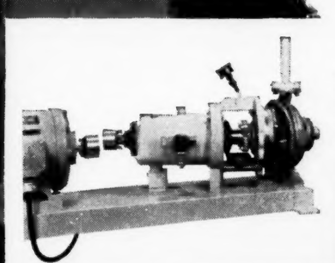


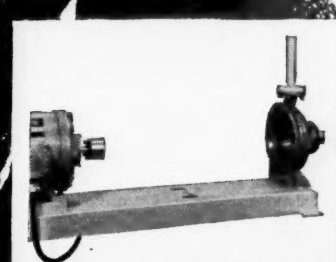
Remove spacer from coupling.

2.



Remove cap screws.

3.



Remove the pump. Note: Neither suction or discharge lines are disturbed, nor is motor or alignment affected.

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under test proved entirely satisfactory, although Hastelloy B was the most suitable of the samples.

The corrosion rate for Hastelloy B of 0.04 and 0.08 ipy. in the two locations is higher than normally considered satisfactory for valve parts. It is also approximately ten times the rate shown in published data for chemically pure acids at the temperature and concentration given.

Tests with actual valves appeared to be warranted, however, because of the poor service experienced with valves then in use. Hastelloy B 6 and 8-in. gate valves had leaks past the gate after two months on stream. The attack was fairly general with many deep pits alternating with hard carbon deposits.

Although attack was not concentrated at the contact faces, it was felt that electrolytic action resulting from contact of the relatively small area of Hastelloy with the large area of carbon was responsible for the rapid failure. Other valves were installed with insulating sleeves and washers on the studs and an insulating gasket with no apparent improvement.

There are holes completely through the gates of 6-in. and 8-in. valves in service approximately three months. The bodies were similarly attacked. At about this time, Hastelloy B reducers following transfer pumps began to corrode and a Hastelloy B sparger was found to have completely disintegrated.

▶ **Inconsistent Results**—These rates were not consistent with published information or the higher rates found in preliminary tests. Samples from the valves and a sample of the acid containing the carbon were sent to Haynes Stellite Co. for laboratory studies.

They ran four series of tests comparing the corrosion rate of Hastelloy B in chemically pure 45% sulfuric acid (Test I) with rates in weak acid from NPCC when samples were insulated (Test 2) and when samples were coupled with graphite (Test 3) and carbon (Test 4). In the galvanic tests, the area of carbon and graphite were 18 times area of the metal. While this indicates area effect, the carbon-metal ratio is still much less than in the actual system. A summary of their report is shown in Table III.

How Carbon Affects Corrosion of Hastelloy B—Table III

Time: 120 hr.
Temperature: Boiling

Test	Corrosive	Galvanic Contact	Corrosion Rate—IPY.
1	45% H_2SO_4 (C.P.)	None	0.004*
2	45% H_2SO_4 (sludge)	None	0.035*
3	45% H_2SO_4 (sludge)	Graphite	0.310
4	45% H_2SO_4 (sludge)	Carbon	1.96

*Average of two tests

▶ **Galvanic Effects**—Corrosion rate for the insulated sample (Test 2) compares closely with the rate determined in Test A of Table II—ten times the rate shown for the C. P. acid.

When galvanically coupled with carbon, the rate of 1.96 ipy. is 490 times that shown for C. P. acid. After these test results it was found by inspection that carbon depositing out from the acid had been bridging over the insulating gaskets in the field tests, thus completing the electric circuit. This would explain why no improvement in life was noted when valves were insulated.

Lead-lined gate and diaphragm valves gave only fair service because of erosion of the lead. Teflon and Kel-F diaphragms, when used in glass-lined or lead-lined valves, failed by embrittlement and cracking after six weeks service. Any erosion of the weir or deposition of solids on the weir also made it difficult to stop the flow with the stiff plastic diaphragms.

Hastelloy D has given good service in acid concentration service and test valves were planned for the "weak acid" system when a new Duriron "Y" valve became available in a size required. It was not known what galvanic effect could be expected with Hastelloy D but Duriron had been demonstrated to be free from such effects.

Duriron "Y" valves, which were then installed, have given good service for more than 1½ years. Some difficulty has been encountered when attempts have been made to tighten flanges excessively to stop leaks at gaskets. But no failures have occurred due to corrosion or thermal shock.

Case III—Erosion Becomes Big Factor

Six concentrators are used to concentrate weak acid to 77% and 92% for sale or further fortification. These units heat the acid under vacuum with bayonet heaters made of tantalum and Hastelloy D. The heaters have given good service although there have been mechanical failures of the tantalum tubes and mechanical failures and weld corrosion of the Hastelloy D tubes.

The acidic vapors from each concentrator stage are cooled in the copper tubes of surface condensers. Corrosion-erosion of the tops of the tubes and the top tube sheets became evident after six months of operation. After 1½ years operation, a sample tube was cut from the condenser which appeared to have been attacked most severely. Corrosion at the rate of 0.02 to 0.045 ipy.

How Alloys Corrode in Hot H_2SO_4 Sludge—Table II

Solution: 45% H_2SO_4 + SO_2 and various hydrocarbons
Time: 900 hr.
Temperature: Test A—250 F.; Test B—300 F.

Alloy	Corrosion Rate—IPY. Test A	Test B
Stainless 316	Total loss	Total loss
Aloyco 20	Total loss	0.57
Aloyco 35	0.25	0.67
Aloyco N-2 (Hast. B)	0.04	0.08
Hastelloy D	0.14	0.24
Chemical lead	0.16*	0.06*
Inco 803	Total loss	Total loss

* Mostly abrasion loss.

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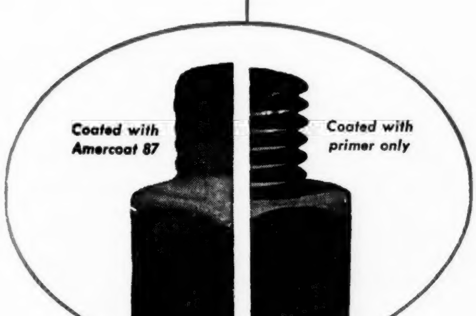

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How Copper Corroded in Surface Condensers—Table IV

Temperature: 200–270 F.
Acid concentration: 0–5% H_2SO_4

Condenser No.	Location	Date	Corrosion Rate—IPY.
3	In roll	Mar. '55	0.02–0.045
	Below roll	....	0.015
	11 ft. from top	....	0.008
1	In roll	Apr. '55	0.019
2	In roll	Mar. '55	0.02–0.03
2	In roll	Dec. '55	0.15–0.02
5	In roll	Apr. '55	0.016

How Test Specimens Corroded in Condenser No. 3—Table V

Temperature: 200–270 F.
Time: 34 days
Acid concentration: 0–5% H_2SO_4

Material	Corrosion Rate—IPY.
Copper	0.022
Aluminum-bronze (Ampco 8)	0.015
Carpenter 20	0.056

How Test Specimens Corroded in Condenser No. 2—Table VI*

Time: 45 days
Temperature: 200–270 F.
Acid concentration: 0–5% H_2SO_4

Material	Corrosion Rate—IPY.
Aluminum bronze (Ampco 8)	0.0046
Ampco 12	0.0066
Ampco 10	0.009
Arsenical	0.009
Aluminum brass	0.009
Silicon bronze	0.018
Type 316 (with high Mo)	0.020
Hastelloy B	0.0038
Allegheny X	0.008
Nionel	0.0019

*Vapor zone.

was found at the top as compared to 0.008 ipy. 11 ft. down. Corrosion rates (Table IV) are approximately the same for the other units.

To determine whether other materials available might be more economical in this service, test specimens were placed in two of the condensers at the entrance to the tubes.

▶ **Aluminum-Bronze Holds Up**—Test results show that Ampco 8 can be expected to give approximately 50% longer service than the original copper tubes. The similarity in rate for the copper specimen and the top part of the tube taken from the exchanger emphasized the importance of erosion due to impingement of acid mist (Table V).

A second test with a larger number of samples was conducted with the samples positioned well above the tubes to reduce the effect of erosion, and to evaluate other possible materials. Results are summarized in Table VI. In this test covering 45 days, Ampco 8 was much superior to other copper-base alloys. It has a deterioration rate only slightly higher than that for the more expensive Hastelloy B and Nionel. When compared with the rate shown in Table V (0.0046 ipy. vs. 0.015 ipy.) it can be seen that erosion in the entry to the tubes accounts for more than half of the metal loss encountered.

On the basis of those tests Ampco 8 has been chosen for all replacement tubes in this service, and inserts to protect the inlet are provided.

Case IV—More SO_2 Than Expected

Piping carrying hot hydrocarbon vapors from one of the stripping towers to the vapor condenser and the condenser itself were made of copper to provide for possible carryover of sulfuric acid mist. After less than one year the copper line had thinned excessively and leaks developed near welds. Tubes in the condenser also were beginning to thin at an abnormal rate.

A Monel line which was readily available was used to replace the copper. Published data reported satisfactory rates for vapors of somewhat similar composition. At this time corrosion test specimens were installed in the system to determine actual rates. Several laboratory analyses of the vapor stream were also taken and it was found that the SO_2 content frequently reached the unexpectedly high concentration of 9%, while H_2SO_4 was rarely present.

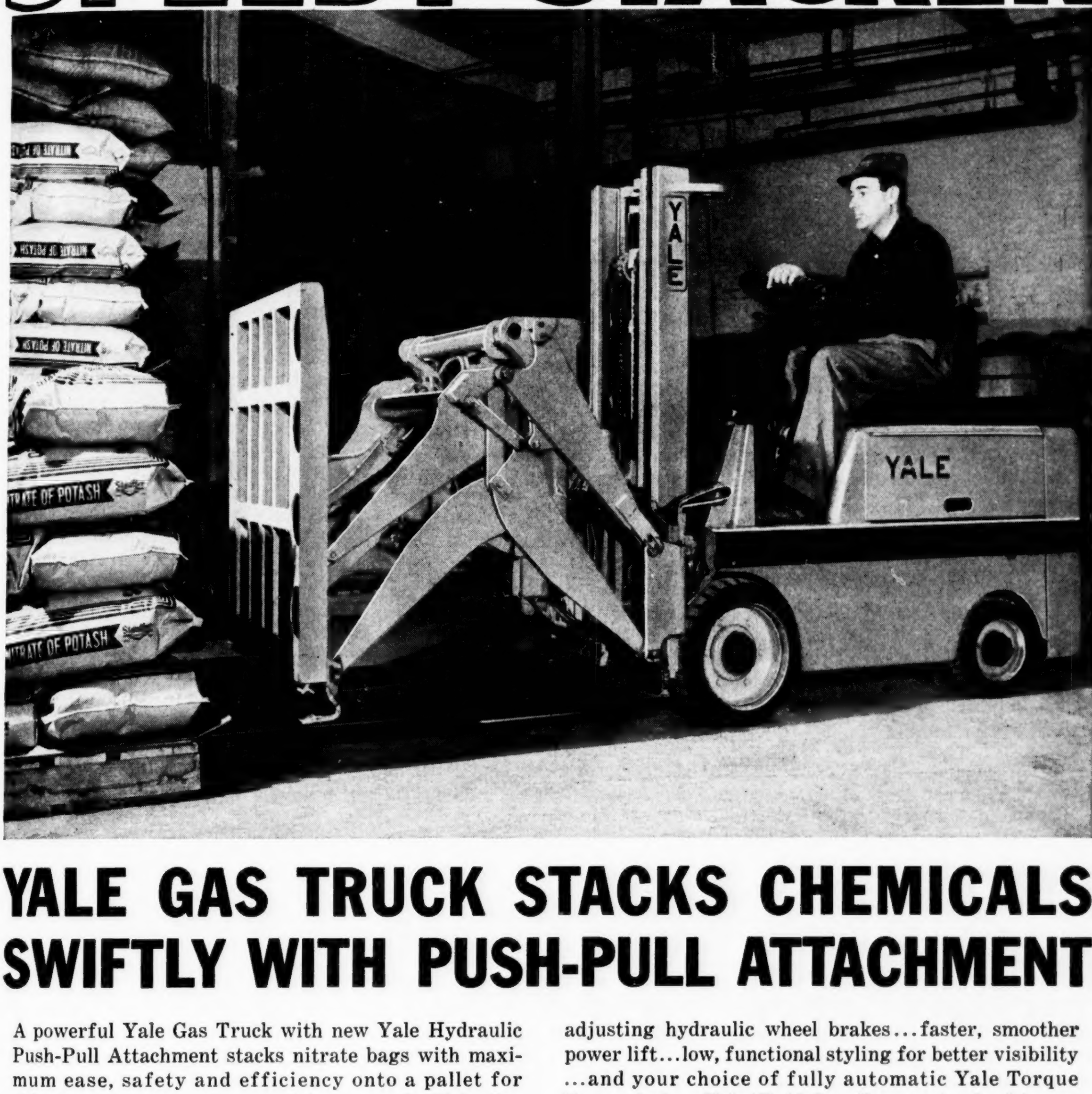
Table VII below shows that the rate for Monel was even higher than copper, as might be expected from the SO_2 concentration, while Type 316 stainless steel was suitably resistant.

Confirming test results, the Monel piping had to be replaced in approximately one year. Type 316 stainless steel has performed more satisfactorily than anticipated and has shown practically no thinning in more than a year.

Tubes in the copper condenser following this vapor line have also corroded quite rapidly and are now ready for replacement. They also become fouled with a scale containing copper sulfide which is difficult to remove after very short service. The corrosion tests previously reported, and the good service from the Type 316 piping, dictated the choice of 316 for the new condenser now ready for installation.

▶ **Copper Superior to Stainless**

SPEEDY STACKER



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How Hydrolyzer Overhead Vapors Affect Metals—Table VII

Temperature: 200 F.
Vapor: Various hydrocarbons + 3-9% SO_2

Material	Corrosion Rate—IPY.
Carbon steel	1.0
Copper	0.038
Monel*	0.057
Type 316	0.023
Alleghany X	0.009

*Monel sample had a hard black scale which was difficult to remove. Under the scale mild pitting had started.

—The copper piping for a similar line from an adjacent tower was expected to carry a similar stream with only slightly less SO_2. After failure of the copper piping replacement was fabricated of Type 316 stainless steel. In approximately four months this line developed leaks at the welds and then corroded through on a 90° elbow.

Process conditions had changed appreciably and there was essentially no SO_2, but there frequently was a carryover of sulfuric acid mist. Before process changes could be made to reduce this carryover of acid a replacement spool of Type 316L also corroded through.

A copper line which has replaced the second stainless steel section has given good service under new process conditions. There is no apparent thinning in over six months.

Other Problems

There have been other corrosion problems of less spectacular nature, which nevertheless require constant attention. For example:

- Steel tubes in a heat exchanger (cooling a hydrocarbon gas containing steam and CO_2 from a catalyst regeneration step) corroded very rapidly. When the high CO_2 content was recognized, ammonia injection was started and tube life increased appreciably.
- Underground water piping has corroded rapidly when subjected to hydrochloric acid spilled on the ground above. Breaks found in the coating permitting this attack were probably due to soil movement. Similar deterioration of coated structural steel has occurred at or near ground level.
- Rapid failure of steel heat exchanger tubes has occurred when water entered systems normally carrying dry acid gases because of failure of seals.
- A steam knockout drum was severely attacked when wet steam eroded a deflection nozzle and impinged on the vessel shell.

These are typical of the many corrosion problems that constantly come up in a large chemical process operation. Laboratory testing and published data can only provide a rough idea of how materials will perform. Corrosion engineers must constantly be alert to the unexpected problems. They must find the causes quickly, and prevent any recurrence.

New Method for Cheaper Titanium Parts

By forming a titanium head using versatile spinning equipment Lukens Steel has broken through a major cost barrier. The method should broaden the use of titanium in the chemical and process industries.

Prior to the Lukens method, titanium heads were made with dies individually constructed for each variation in size and shape. In a joint research program with Rem-Cru Titanium, a Rem-Cru A-55 commercially pure titanium plate was placed on a spinning machine and worked at a minimum temperature of 600 F. The plate had previously been heated under close temperature control to 1,400-1,450 F. With standard equipment an elliptical head 16-in. in diameter and ¼-in. thick was spun.

This is the first time a head of solid titanium has been formed without costly dies.

Fabricating Zirconium Alloy Tank

A large tank of Zircaloy-2 for an experimental homogeneous nuclear power reactor has been successfully fabricated at the Newport News Shipbuilding & Drydock Co., Newport News, Va.

Zircaloy-2 sheets, ⅛-in. to ⅜-in. thick, were pressed into the required conical and spherical shapes for the main body of the tank and machined forgings were used for the inlet and outlet pipes. The difficult assembly called for welding the various conical and spherical sections to each other and this to the inlet and outlet piping.

Zirconium and zirconium-rich alloys are extremely active chemically. They react readily with atmospheric and other contaminants, such as nitrogen, carbon, and oxygen, to form brittle compounds and solid solutions in the weld area. As a result, complete shielding of the welds is necessary, and the Heliarc welding method (inert-gas) was used.

First, an insert wire of Zircaloy-2 was manually tack-welded in the joints. Then the joints were fusion-welded mechanically using swaged Zircaloy-2 filler wire and a shielding apparatus designed to conform with the shapes of the welded surfaces. This water-cooled apparatus, which directed inert gas at and behind the torch was spring-mounted against the spherical surfaces. The reverse sides of the welds were also shielded.

In the spherical sections, perforated copper tubing directed shielding gas to the weld area. In the conical sections, the ends of the assembly were plugged and the enclosed area was flooded with inert gas.

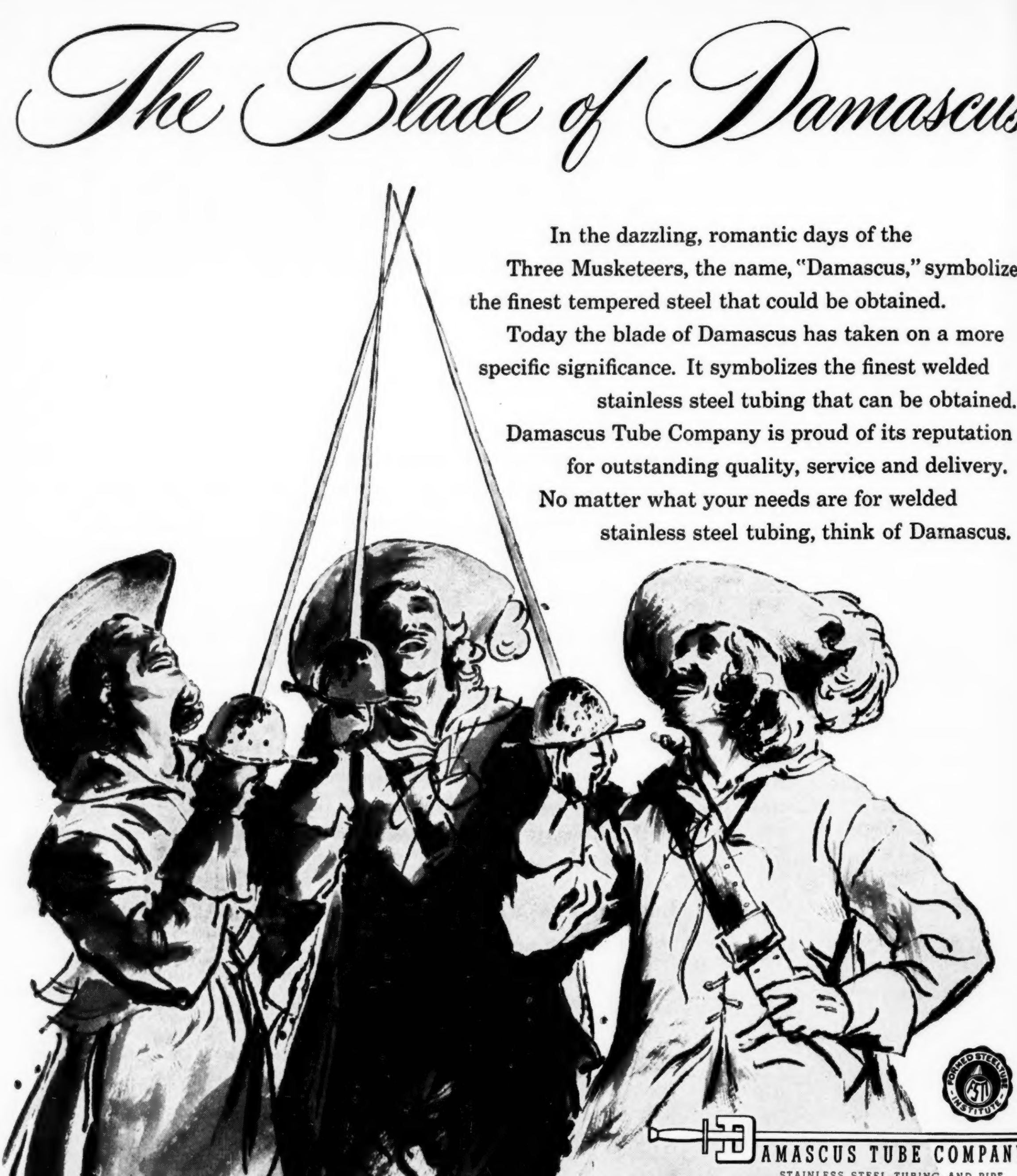
The most complex sub-assembly involved was the welding of perforated Zircaloy-2 disks cross sectionally inside the 30- and 90-deg. sections of the main body. These screens, which facilitate uniform flow of the liquid fuel through the tank, were manually welded.

Chemical Engineering

People

FEBRUARY 1957

Department Index


The Blade of Damascus
In the dazzling, romantic days of the Three Musketeers, the name, "Damascus," symbolized the finest tempered steel that could be obtained.
Today the blade of Damascus has taken on a more specific significance. It symbolizes the finest welded stainless steel tubing that can be obtained.
Damascus Tube Company is proud of its reputation for outstanding quality, service and delivery.
No matter what your needs are for welded stainless steel tubing, think of Damascus.
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GREENVILLE, PENNSYLVANIA

In your company . . .

In your department . . .

In your job . . .

You Can Cultivate Executive Potential

Use these few simple suggestions to help stimulate the development of executive talent in engineers. They can fit right into daily operations.

F. B. Odasz, Husky Oil Co., Cody, Wyo.

With more and more companies looking on their engineers as a prime source of future executive talent and with a bewildering array of executive training programs in use, it's easy for both engineers and management to lose sight of the fact that executive development begins in the department. It is only there, where the engineer spends most of his working time, that such training can take hold and here that its results can be measured on a continuing day-by-day basis.

Whether group leader or company president, development of all people reporting to him is part of the job of every superior. It's a task he can't delegate to the personnel department, a management consultant or an educational institution by using a patent-medicine-type of executive development program.

Development weaknesses and ills have to be diagnosed and the treatment prescribed by those in first-hand contact with the situation, if the cure is to be effective.

Welcome Expert Advice, But . . .

Naturally, those faced with this task wouldn't be wise to ignore the counsel of experts both inside and outside of the company. Their advice, interpretation of special techniques and observations on a program's progress may make the difference between mediocrity and the successful fulfillment of the program.

But it's up to the individual superior to create in his operation a climate that encourages development and it's up to him, to give his subordinates the means, the opportunity and the encouragement that brings it about. Nobody can do this job for him.

More Art Than Science

Many, if not most, major chemical companies now use formalized procedures in training programs for potential supervisory personnel. As a result, chemists and chemical engineers now have greater opportunities than ever before to assimilate the background in non-engineering areas that they will need in supervisory and management positions.

But formalized or not, executive training is still more of an art than a science. Programs that have been a resounding success in one company or in one division of a company may flop miserably in a different environment with different people.

With this in mind, here are a few techniques that have been used successfully over the past few years and that could probably be adapted to your operation with a minimum of trouble. None of these represents a full-scale, schedule-shattering program. But fitted into your group's daily operations they can add up to a high-powered stimulus for the development of executive potential in your group.

Use Your Meetings to Train

Properly handled, group or departmental meetings can be a valuable means of imparting the broader viewpoint needed by the executive.

One way to do this is through periodic reviews of current problems or projects in seminar fashion—with even the newest or most inexperienced member of the group expected to participate—instead of the superior doing the reviewing in regal aloofness.

Application of creative thinking techniques (*Chem. Eng.*, July 1956, p. 218) in these meetings can serve the double-barrelled purpose of opening new avenues of attack on problems and developing the imaginative scope of those taking part.

Try This Kind of Meeting

To put emphasis on the broad point of view, embracing both technical and non-technical areas, we have used a series of meetings based on the "Chemical Business Handbook" (edited by John H. Perry, McGraw-Hill, New York, 1954, $17).

This work contains twenty chapters each dealing with some phase of the operation of a chemical company — industrial relations, sales, research, finance, safety and so on. We found that the material applies in most respects to the petroleum business, too.

Each member of the department studied a chapter of interest to him and at a department meeting he reported to the group on the principles discussed in his

F. B. ODASZ *was recently named manager of Husky Oil's newly created development and control division. He's a chemical engineer from Brooklyn Poly.*

chapter. Head of the company group involved was invited to be present in the capacity of guest-expert to interject information on the company's application of the author's ideas—or explain why the company rejects the author's contentions.

This directed guidance bridged the gap between the book and the company's operations, gave most of the men in the group their first real look at what makes their company tick and brought home countless lessons on company organization and business practices and procedures.

Sessions would start at 4:15 p.m. and, though scheduled to end at five, by mutual consent they would often run on to six to accommodate a lively discussion period. As a follow-up, the man who reported on the chapter discussed would prepare a written abstract and copies would be distributed to each department member and the guest-expert.

Now each member of the department has an abstract of Perry's entire book as well as a familiarity with its relationship to the company's operations.

Take Opportunities in Writing

That never-ending stream of reports that management requires also furnishes opportunities for development.

Some heated comment has appeared in recent technical journals about the merits of having a ghost writer do the actual writing of scientific and engineering reports. In my opinion, there is merit in this approach only if the scientist or engineer plans a lifetime of pure research work. Relieving him of the chore of doing the actual writing of his reports and papers may help increase his research productivity.

But when you're trying to train potential executives, each man should prepare his own reports and be required to interpret his work for his reader and offer clear-cut recommendations for future action. This is important because ability to communicate ideas and to get action on them is one of the most vital skills of the effective manager.

Management's insistence on clear and accurate interpretations and logical recommendations in all reports is necessary if such reports are to be used for aiding a man's development. Simply presenting facts or data usually doesn't give the reader a sufficient basis for making a decision. Having to supply interpretation and recommendations, the engineer learns to put himself in management's shoes, to view his facts and data from the position of management's needs.

For Getting More Practice

Further practice in effective communication can be gained by writing papers and articles for technical journals. Since these endeavors also aid the man's professional development and bring professional recognition to him and his company, they should be encouraged wherever possible.

To use such writing for teaching improved communication skills, it is recommended that for a man's first paper the superior write the first draft and let the man write the second. A final draft can then be prepared in a joint session. In this manner the new author can learn the techniques of presenting technical information while reserving his freedom of expression.

For his next one or two papers the procedure can be reversed—the man preparing the initial draft and his superior acting as an editor. You may be surprised at how rapidly most engineers can learn sound writing techniques in this manner. By his third or fourth paper the man has usually progressed sufficiently to do first-rate work on his own.

Planned Conferences Are Spurs

Among the most fruitful methods for inculcating an awareness of the need for development and for guiding a man along the proper path are planned, periodic, private conferences with him.

Key words here are *planned* and *periodic.*

Infrequent, spur-of-the-moment meetings that catch both parties virtually unawares and concerned with other matters just don't go as far as they might in aiding the engineer's development. And as opportunities lost through lack of foresight they may actually work against it.

Such interviews can be a blight or a blessing depending mainly on the superior's skill in discussing the various aspects of the engineer's training and development. The superior should remember that the impression and the feelings the engineer takes away from these meetings also affect his family and their attitudes toward the superior, the company and the job itself. These family attitudes are a continuing influence on the engineer and his development. They shouldn't be underestimated.

Handle Them Objectively

Properly handled, these interviews can help the man uncover his weaknesses, build his pride in his strong points and coach him on ways to improve his overall performance. But the superior must take care that the interview never lapses into the stereotyped "worker-boss" discussion in which the worker spends his time defending himself against the boss' accusations and neither really learns much.

Stressing appreciation of the man's strong points can often minimize any threat to his self-esteem when his weaker areas are under discussion. It can also help in establishing a feeling of objectiveness in the discussion that keeps it on a high plane. By fostering more objective self-study of his behavior on the engineer's part, this will leave him with a feeling of accomplishment and a desire to strengthen current weaknesses.

Next Month: Motivating and Directing Technical Men

A problem that faces all levels of management is every organization is that of motivating people at lower levels to do the best job they can. Next month, You & Your Job will explore this problem as it applies to technically trained men and women and offer a few concrete suggestions for solving it. We'll give the task of handling group meetings and that of giving assignments the most attention.

One topic worth discussing in these conferences is the amount and kind of outside reading that the engineer does. In addition to contributing to the objective nature of the talk, this information helps the superior to judge both the immediate interest and the long-range potential of the man. It has also been found to serve as an excellent spark for motivating the man to greater effort.

Let Him Run Things

A final technique—to be used judiciously—is to arrange special days for each man during which he literally runs the department. Give him the opportunity to step into the superior's shoes, dictate the answers to correspondence, handle phone calls, make decisions and, in general, be the boss for that day.

In the beginning the superior will have to sit near to help handle communications and fill in the background in decision-making situations and, if need be, over-rule a particularly bad decision and explain how the error was made. But the superior is liable to be surprised at how readily some of his men learn to play his role after a reasonable training period.

This type of training for his men helps the superior fulfill one of the basic requirements for his own advancement—availability of a trained replacement.

Daily Training Is Important

An important feature of most successful executive development plans is that every day is a training day. Lectures, job rotation, outside schooling and so on are well and good, but they can only supplement the day-to-day training the man receives on the job.

Day-to-day training doesn't mean hovering over the trainee ready to pounce on mistakes. It means intelligent guidance, encouragement and criticism from the first day's orientation on. And it's the job of every level of management.

SALARIES

. . . *Up About 8.6%*

In 1956, engineers and other professional employees in American industry earned about 8.6% more than they earned in the prior year, according to a survey made by the American Management Association's Executive Compensation Service.

Most of the surveyed companies said they gave salary increases to their technical and administrative personnel during the period covered by the study (May 1955 to May 1956). The 8.6% over-all average increase compares with an increase of 4.5% for the prior year.

Percentage rise in engineers' salaries is higher than that of any of the other executive and specialized groups studied by AMA.

The latest study covered more than 31,400 engineers, scientists and administrative personnel in 49 different industries at five levels of responsibility. According to AMA, this is the largest and most comprehensive survey of its kind ever conducted. It's said to offer a complete picture of the market for technical personnel in the United States today.

Engineers with less than one year of experience are earning a median salary of $5,300/yr., regardless of their specialization, the survey shows. Those with from one to three years in industry have a median salary of $6,500/yr.

Highest salaries reported in the survey go to certain non-management specialists in research and exploration who have some administrative duties. In a few cases these individuals earn up to $19,000/yr. Physicists and mathematicians with similar administrative functions aren't far behind, averaging up to $15,000/yr.

SALARIES

. . . *Top Man's Rises 6.8%*

Today's captain of industry—the top executive in a major corporation—also gets pay hikes. Harvard Business Review's latest report on the salaries of top-level men (covering only 1955) shows that the chemical industries chief executives averaged a 6.8% increase in compensation over the prior year. Top men throughout all industry averaged 6.3%.

In drugs and cosmetics the rise was 4.4%. Food industry chiefs averaged a rise of less than 1%. Paper and paperboard industry leaders scored a 7.7% boost. In petroleum and natural gas the increase was 4.9%. And in the rubber industry top men averaged a 15.9% raise.

The study, conducted by Arch Patton of McKinsey & Co., a management consultant firm, also related the top man's compensation to both the sales and profits of his company. The chemical industry pays its chief executives slightly more than the industry average on a sales basis, slightly less in terms of profits.

All chemical firms with annual sales over $250 million pay their top men more than $100,000/yr.

In the chemical industry the second highest paid executive gets a median 77% of the top man's compensation; the third highest gets 60% and the fourth highest, 59%.

License Helps Available

Reprints of CE's three-article series of helps for chemical engineers interested in getting their professional license are again available. These articles detail the requirements you'll have to meet in your state, tell how to pass the written exam and show you how to go about registering in other states.

All three articles have been compiled into a single reprint. Price 50¢. For fastest delivery check Reprint No. 85 on the Reader Service cards you'll find just inside the back cover.

PEOPLE . . .

TECHNICAL BOOKSHELF

R. K. GITLIN

Heat-Exchanger Design

Compact Heat Exchangers By W. M. Kays and A. L. London. National Press, Palo Alto. 156 pages. $5.

Reviewed by W. Schotte

Written by two experts, this book contains an excellent summary of design information on heat exchangers. Increasing interest in extended surfaces to transfer heat demands such know-how as is displayed in this monograph. Seven years of experimental and theoretical work by the authors and their coworkers have been covered. Results of other investigators have been included for the types of heat exchangers not studied by Kays and London.

Four major types of compact heat-transfer surfaces have been considered: tube banks—including both circular and flattened tubes; plate-fin surfaces—with a variety of fin types; finned-tube surfaces—with both circular and flattened tubes and various types of fins; screen and sphere matrix surfaces. In all, 88 surface configurations are presented. Most of the basic heat-transfer and flow-friction data have been given as the Colburn factor, $N_{St}N_{Pr}^{2/3}$, and friction factor, f, versus Reynolds number, N_{Re}.

In addition to basic design data, a chapter is devoted to heat exchanger performance theory, using the concepts of effectiveness and number of heat-transfer units (NTU). This method eliminates the trial-and-error procedure normally required to determine terminal temperatures for a given exchange area or the heat-transfer area when terminal temperatures are known. Graphs of effectiveness versus number of heat-transfer units are given for the usual flow arrangements of heat exchangers.

Other chapters are devoted to additional design information. Simple approximations are recommended to account for temperature-dependent fluid properties. Aside from flow-friction data, contraction and expansion losses have been covered for complete determination of pressure drops. Use of data and theory is illustrated by sample problems in an appendix. Another appendix contains physical properties of combustion products of some common fuels.

This book is a fine source of data for a wide variety of heat exchanger types. But, the occasional user may not find it a simple reference source, as familiarity with all chapters will be needed for most applications. Material is presented in a very concise form and will require thorough study for a good understanding. Also the reader is left to his own devices for the selection of the best type of extended surface to do the job. Recommendations for a preliminary selection of the type of heat exchanger would have been most welcome. The thorough compilation of factual information on compact heat exchangers will make this monograph a must for heat-exchanger designers.

Economic Evaluation

Chemical Process Economics. Edited by J. James Hur. Reinhold Publishing Corp., New York. 115 pages. $3.

If you have only a passing interest in analytical techniques for evaluating chemical processes, then you can afford to pass over this little book. Because its real value, in this reviewer's opinion, lies in the chapter by Du Pont's A. E. Lawrence on how to prepare cost allocations and "roll-ups" in a multiproduct chemical manufacturing complex.

As Lawrence points out: "The preparation of cost roll-ups involves considerable labor, but the roll-up saves many times the labor involved in its preparation by providing accurate, rapid answers to management ques-

tions without making special studies. More importantly, the prompt answers save valuable management time." He suggests that availability of high-speed computers may lead to wider use of roll-up techniques where manual calculations have been too time-consuming.

The other six chapters in this book, consisting of the papers presented at an all-day meeting of the Philadelphia-Wilmington section of AIChE, offer little of value which isn't available in better form in existing textbooks such as Schweyer's "Process Engineering Economics" or Tyler's "Chemical Engineering Economics." The only other bright spots we found were a "cost accounting flowsheet" and a brief exposition of the "investor's method" for economic analysis.—CHC

Worth Close Study

AN INTRODUCTION TO MODERN ORGANIC ANALYSIS.. By S. Siggia and H. J. Stolten. Interscience Publishers, New York. 250 pages. $4.50.

Reviewed by M. E. Auerbach

The senior author is already well known for his book, "Quantitative Organic Analysis via Functional Groups," and for numerous lectures on the same subject before technical societies and the staffs of industrial and academic organizations. The present book is the printed record of these lectures, presumably enlarged and modified to meet the needs of a more permanent presentation.

Of the twelve chapters, the first surveys briefly, but competently, the general problem of organic analysis and the tools available to solve such problems. In the following chapters, details of technique and advice on interpretation are given for functional group analysis, numerous instrumental methods and determination of physical constants. Over and over, the need is stressed for surveying the individual problem in its larger context and for using more than one approach and appreciating the inter-relationships of various approaches.

This reviewer, who has had long association with organic analysis, considers this an important book—well worth close study. The format, with problem questions and answers following each chapter, makes it potentially useful as a text for advanced chemistry students.

Storehouse of Information

CATALYTIC, PHOTOCHEMICAL AND ELECTROLYTIC REACTIONS. Technique of Organic Chemistry, Vol. II. 2nd ed., revised and augmented. Edited by Arnold Weissberger. Interscience Publishers, New York. 551 pages. $11.50.

Reviewed by F. C. Nachod

As our knowledge increases, so do our textbooks (and their prices). The progress, within eight years, in the three fields which form the subject matter of this book can be shown dramatically in a table:

	1st Ed. (1948)	2nd Ed. (1956)
Pages	229	556
Illustrations	66	84
Tables	9	77

The first two sections have been revised and materially enlarged. The third, while not radically altered, now contains an extremely useful appendix which lists about 500 electrolytic reactions (former edition, 62 reactions).

All users of the "Technique Series" will be delighted with this volume.

35th in a Series

ORGANIC SYNTHESES. Vol. 35. Edited by F. L. Cairns. John Wiley & Sons, New York. 122 pages. $3.75.

Reviewed by F. K. Kirchner

The present volume of "Organic Syntheses" marks the 35th year of a valuable publishing venture. American and foreign chemists have shared their experiences with us as contributors to this volume.

Annotated procedures for the preparation of 38 different compounds are recorded. All are of

interest to the organic research chemist; some may be of value to the chemical engineer.

As in previous volumes, reproducibility has been insured by having each set of directions checked by another group of chemists. Safety precautions, names and addresses of manufacturers and identification of apparatus by catalogue number are added desirable features. The time-saving device of carrying a cumulative subject index for volumes 30-35 inclusive has been continued.

Thanks to the editor and publisher for a job well done.

Briefly Noted

DATA FOR COST ESTIMATION—IMPERVITE STANDARD IMPERVIOUS GRAPHITE PROCESSING EQUIPMENT. 32 *pp. Available on letterhead request. By G. Sarvadi. G. Sarvadi, Falls Industries, Inc., Aurora Rd., Solon, Ohio.* Designed to help with cost estimation and selection of impervious graphite processing equipment (including all standard equipment produced by Falls Industries under Impervite name). Covers heat exchangers (tube and shell, cubical, cross bore, plate, bayonet), cascade coolers, HCl absorbers, towers, centrifugal pumps, rupture disks, pipe, fittings and valves. Detailed costs furnished in \$/sq. ft. of transfer area or other convenient unit.

CAREERS IN NUCLEAR SCIENCE AND ENGINEERING. 34 *pp.* 10¢. *Atomic Industrial Forum, 3 E. 54th St., New York 22, N. Y.* Illustrated booklet based on proceedings of a conference for high school science students held last September at Navy Pier, Chicago. Features talks by E. Walker, president of Pennsylvania State University; L. R. Hafstad, vice president and director of research of General Motors Corp.; F. L. Hovde, president of Purdue University.

ENCYCLOPEDIA OF AMERICAN ASSOCIATIONS. \$15. *Gale Research Co., 424 Book Tower, Detroit 26, Mich.* A listing of more than 5,000 associations, societies and chambers of commerce divided into six basic sections: Trade, Business, Agricultural and Governmental; Scientific and Engineering; Educational and Social Welfare; Medical and Health; General Associations

(fraternal, veteran, athletic); Chambers of Commerce (national, state, local, foreign). Each association listing includes address of national headquarters, executive secretary, number of members and staff, year founded, description outlining membership and purpose of group.

BIBLIOGRAPHICAL ABSTRACTS OF METHODS FOR ANALYSIS OF SYNTHETIC DETERGENTS. 44 *pp.* $1.50. *American Society for Testing Materials*, 1916 *Race St., Philadelphia* 3, *Pa.* Updates and supersedes 1953 edition, contains 311 abstracts arranged chronologically from 1888-1955. Should be useful to detergent analysts and others interested in field of textiles, dry cleaning and laundering; those concerned with purchasing detergents for institutional maintenance.

SYMPOSIUM ON SPEED OF TESTING NON-METALLIC MATERIALS. 86 *pp.* $2.50. *American Society for Testing Materials*, 1916 *Race St., Philadelphia* 3, *Pa.* Covers testing--from very slow to very rapid rates—of wood and wood-base materials, glass, yarns, plastics, rubber, concrete, paper. Illustrated with graphs, charts, photographs.

MORE NEW BOOKS

CHEMISTRY AND TECHNOLOGY OF LEATHER. Vol. 1—Preparation for Tannage. Edited by F. O'Flaherty, W. T. Roddy and R. M. Lollar. Reinhold. $14.

DEFECTS AND FAILURES OF METALS. By E. P. Polushkin. Elsevier. $12.50.

ION EXCHANGE AND ITS APPLICATIONS. Macmillan. $7.50.

MOMENTUM TRANSFER IN FLUIDS. By W. H. Corcoran, J. B. Opfell and B. H. Sage. Academic Press. $9.

ORGANIC SYNTHESES. Vol. 36. Edited by N. J. Leonard. Wiley. $3.75.

REACTIVE INTERMEDIATES OF ORGANIC CHEMISTRY. By J. E. Leffler. Interscience. $6.

STRESS CORROSION CRACKING AND EMBRITTLEMENT. Edited by W. D. Robertson. Wiley. $7.50.

TECHNIQUE OF ORGANIC CHEMISTRY. Vol. III. 2nd ed. Part I—Separation and Purification. Edited by A. Weissberger. Interscience. $17.50.

UNIT OPERATIONS OF CHEMICAL ENGINEERING. By W. L. McCabe and J. C. Smith. McGraw-Hill. $10.50.

PEOPLE . . .

MEET YOUR

Frank L. Rubin

HOW TO SIMPLIFY SHELL SIDE CALCULATIONS. PAGE 257.

Among the many people in the world who operate best on a busy schedule is heat transfer expert Frank Rubin. Rubin is a sales engineer for the Downington Iron Works, Inc., Downington, Pa. He's responsible for the preparation of sales proposals for tubular heat transfer equipment. These duties include the complete process design of equipment for thermal conditions, mechanical design for compliance with code and customer requirements, detailed development of material costs, and determination of shop labor needs for construction.

Rubin was technically trained at Brooklyn Poly and at Cooper Union's School of Engineering. He earned his chemical engineering degree at the latter school in 1946. Meanwhile, though, he had already acquired a liberal arts degree from Brooklyn College.

Over the years, he has had extensive experience as job and process engineer, research chemist, draftsman, and heat transfer engineer. He has published a great deal in all of these fields and has plans for several other papers.

Besides his active membership in the AIChE and the ASME, he's busy continuing his education at night at Temple University's School of Business Administration.

Rubin's pet home project consists of trying to grow a first-

AUTHORS

M. A. GIBBONS

class lawn. To date, he reports considerable success and has developed a "firm belief" in the qualities of Merion Blue Grass—a locally developed product.

Swimming and ice skating are two sports he enjoys, in particular, because the family can share them with him. But Rubin's friends report that he's really primarily a baseball fan—an avid rooter, in fact, of the Brooklyn Dodgers for nearly three decades.

In regard to his article he tells us Downingtown Iron Works will furnish, on request, a table of tube counts for various shell diameters and types of construction.

Alfred H. McKinney

USE "K'S" TO SPEED FLOW CALCULATIONS. PAGE 263.

A man with an eye on the future of instrumentation is chemical engineer Alfred McKinney.

McKinney studied at Drexel Institute of Technology where he earned his B. S. in chemical engineering in 1932. His first job was with the Philadelphia Quartz Co. and he stayed with the firm nearly 20 years. Since 1951, he has been associated with Du Pont's engineering department.

At home, his main activities are work on miniature control devices in his basement work shop. He's also getting fairly adept at helping his two daughters with their school projects.

AUTHORS . . .

His concern with instrumentation has resulted in one interesting prediction. He thinks the day will come when we can simulate complete plant operations—completely controlled automatically—on the lab bench. Small scale tryouts will be less expensive in terms of time, materials, and equipment, in developing needed process and control data too.

For some years (1939-1951) McKinney taught mathematics and physics at Drexel's evening school. Recently, he also found time to write the sub-section on laboratory control apparatus for Considine's forthcoming handbook on instrumentation and control.

Among the societies in which he is an active member are the following: American Institute of Chemical Engineers, American Chemical Society Tau Beta Pi, the Delaware Society of Professional Engineers, and Franklin Institute. He was also a charter member of the Philadelphia Instrument Society which later became the Instrument Society of America.

Some years ago, McKinney became quite a serious student of bridge. So much so, in fact, that he began to teach the subject and to play in national tournaments. But now, he says, activities are limited to regular Friday night rubber games with old cronies.

M. Nadel

TO HIT TARGET DATE, CONTROL YOUR CONSTRUCTION SCHEDULE. PAGE 261.

Chemical operator-trainee, technical coordinator, process engineer, project engineer and

field engineer—so reads the experience record of M. Nadel, this month's Chemical Engineering construction expert.

While Nadel's article is ample evidence of how he has applied this experience on the job, we think he may find such experience useful in off-hours since he is a self-styled do-it-yourself victim.

At Day & Zimmerman, Inc., Philadelphia, Nadel has spent the past five years as process, project and field engineer. He has worked on the design and construction of process plants and in the preparation of engineering and construction estimates, reports and proposals.

At his Philadelphia home, Nadel and his wife are busy integrating November-baby Amy into the life of their household. And in the Nadel home that means—among other things—learning to appreciate high-fidelity jazz. How this integration may affect golf and tennis activities has not yet been predicted.

Before he became a registered professional engineer in Pennsylvania, Nadel earned a B. S. in chemical engineering at West Virginia University, in 1949, and took graduate studies at Stevens Institute of Technology in 1951.

Nadel learned his practical engineering the hard way as a chemical operator-trainee in the manufacture of essential oils and fine organic chemicals at Norda Essential Oil & Chemical Co., Boonton, N. J. Then he became a technical coordinator at Picatinny Arsenal, Dover, N. J. Here, Nadel coordinated activities of the utilities, traffic, inspection and production units associated with production of various propellants and explosives.

Nadel is an associate member of the Philadelphia-Wilmington section of the American Institute of Chemical Engineers. At present, he is also his firm's representative to that section.

Born and raised in Boonton, N. J., Nadel has spent most of his thirty years in the Middle Atlantic area. And, if Day and Zimmerman has anything to say about it he'll stay on and spend the next thirty there too.

George Weber

OUTPUT UP WITH REVAMPED CONTROL. PAGE 248.

Stauffer Chemical's George Weber, manager of the firm's Brooklyn plant, "started at the bottom" and during the ensuing 38 years worked his way up to his present position.

Now 63, Weber—a native Brooklynite—actually got his technical start when, during World War I, he served in the Chemical Warfare Service, in this country. After joining Stauffer, he educated himself in his chosen field by night school studies at both Pratt Institute and Brooklyn Poly.

Commenting on today's widely publicized shortage of technical talent, Weber feels that more emphasis and attention should be focused on the high school student and the high school curriculum. It is here, he says, where a boy's educational future is charted and determined. To succeed in chemistry—a field, incidentally, where we've only begun to scratch the surface, Weber states—"requires not only the usual ingredients of hard work, and talent or aptitude, but also careful selection of courses."

Retiring and self-effacing, Weber is popular with his fellow employees and regarded as one of the elder statesmen in the organization with a seniority "close to the top."

Outside interests range from the ACS to the Brooklyn Chamber of Commerce and the Federal Grand Jurors Assn.

He is also, as might be expected, a Dodger fan which may help explain his interest in the Borough's Chamber of Commerce activities.

G. Douglas Gardner

SOLVING UNEXPECTED CORROSION PROBLEMS. PAGE 292.

National Petro-Chemicals' G. Douglas Gardner is the firm's senior inspection engineer.

Gardner earned his B. S. in metallurgical engineering from the University of Utah in 1944. From 1941 until 1947, he worked as a metallurgist at the Salt Lake experiment station (U. S. Bureau of Mines) on hydrometallurgical research.

At that time he transferred to the coal-to-oil demonstration plant at Louisiana, Mo., to work on metal problems connected with the high-temperature, high-pressure processes under study there.

In 1953 he joined National Petro-Chemicals and is now in charge of the inspection department and its four inspectors.

Gardner's specialties are corrosion control and materials selection, as well as material design for high-temperature and high-pressure processes.

He has published papers on oxidation of metal sulfides, extraction of metal oxides from ores, corrosion problems and various aspects of metallurgy.

Doug Gardner's family consists of his wife, Fern, and four sons: David, 15; Robert, 11; Richard, 9; and Mark, 5.

In his spare time, Doug enjoys taking camping trips with his sons to nearby areas. He is also an avid photographer and likes to watch football—pastimes he can also enjoy with his children. His most useful hobby, though, is carpentry. His skill in this area has done a lot to beautify the Gardner home.

Gardner is a member of the American Society of Metals.

AUTHORS . . .

Wallace R. Gambill

HOW TO ESTIMATE ENGINEERING PROPERTIES. PAGE 235.

Union Carbide's Wallace Gambill spends most of his time working with the firm's Nuclear division in Oak Ridge, Tenn. Just now he's connected with the ANP (Aircraft Nuclear Propulsion) project and working on heat transfer and physical property studies under H. F. Poppendich.

Going back a bit, Gambill graduated from Georgia Tech in 1952 with a B. S. in chemical engineering. On June 6—the same day he graduated—he was also married. The Gambills now have two daughters (aged 1½ and 3 years).

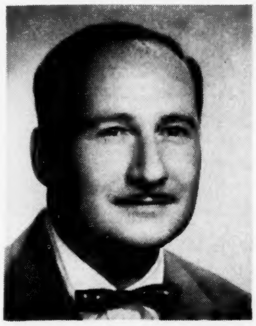
After graduation, Gambill started working for Carbide & Carbon in So. Charleston, W. Va., in the engineering department. Some of his time during this period was spent doing process design work for a "Dynel" synthetic fiber plant. The rest of the time was spent with C. H. Gilmour in heat transfer design and special studies.

Then, for some months before he left Charleston, he worked with A. K. Doolittle, senior scientist of Carbide's research department, working on a comprehensive theory of the liquid state.

Outside the office, Gambill enjoys photography and hunting as hobbies. Another of his pasttimes is cave exploring or "speelunking" Gambill estimates that he has explored about twenty-five undeveloped caves throughout the South.

While in college, Gambill won the Perry award for freshman English, the AIChE Nat'l

Scolastic award for the Georgia Technical Chapter and hit the dean's list every quarter.



Anthony A. Romeo

A FUNCTIONAL PIPING FLOWSHEET. PAGE 255.

Of his twenty-two years of design and drafting experience, Anthony Romeo has spent twenty years in the piping field.

Just now, Romeo is with the James P. O'Donnell firm, New York, in charge of a group responsible for the piping design and layout of chemical plants and refineries. Romeo has been with the firm since 1948, except for a one-year stint with Scientific Design—where he was on a similar assignment.

Twenty years ago, Romeo got his first job in the piping field at the Navy Yard in Brooklyn, N. Y., and—not long after—as supervisor of shipbuilding at Newport News, Va. Later, as associate marine engineer, at Newport, he took charge of the design and layout of piping systems for naval vessels.

Romeo studied mechanical engineering at City College, New York; marine engineering at NYU; and specialized in pipe stress analysis at Pratt Institute.

Like another of our February authors—G. Douglas Gardner—Romeo prefers woodworking household items to other pastimes. So far, he has polished off a living room set in modern design and soon he plans to tackle the job of turning out furniture for the dining room. Romeo also plays chess, golf and collects jazz records—especially discs made by small combos.

Romeo lives in East Northport, L. I.

AUTHORS . . .

Earle F. Young Jr.

NEW TOOL ANALYZES MIXING STAGES. PAGE 241.

Earle Young is a graduate of Carnegie Institute of Technology, where he received a B. S. in chemical engineering in 1949.

For the first two years of his career in industry, Young was employed as a research engineer with Babcock & Wilcox Co., in Alliance, Ohio. Then, in 1951, he joined Mathieson (later Olin Mathieson) Chemical Corp. at Niagara Falls, N. Y.

Here, at different times, he handled a variety of assignments doing research, cost and project engineering work. He became a project group leader —a position he held until the end of 1955.

In 1956, he joined Jones & Laughlin as a process engineer in the chemical engineering services department. Last July, he transferred along with the department to the research division.

Three months later, he was promoted to senior development engineer—with wider responsibility in pilot plant and development programs (in the fields of ore and raw materials, by-products, and pollution abatement).

Young is a member of AIChE and a charter member of the American Assn. of Cost Engineers. He was co-author in two series of articles, "Simple Reactor Design" and "Reactor Design for Complex Reactions," which have appeared as a part of the CE Refresher series in this magazine. Evenings, he returns to his alma mater where he is an instructor in CIT's night school.

Young is married to the former Rosalie Coleman—also a

CIT graduate—and has two sons and a daughter. He makes his home in Mount Lebanon, Pa.

He is the son of the late Earle F. Young, who was vice president of Weldon & Kelly Co., Pittsburgh, Pa.

Herbert Briggs Sargent

HOW TO DESIGN HAZARD-FREE SYSTEM TO HANDLE ACETYLENE. PAGE 250.

Linde Air Products' Herbert Sargent, who is senior technical consultant at the firm's Speedway Engineering Laboratory, brings to acetylene technology the wisdom gained during a twenty-year association with this "fickle" material.

Sargent joined Union Carbide & Carbon Corp. in 1936 as a research engineer at the Acetylene Research Div. of Prest-O-Lite Co. (now Linde Air Products Co.). During his years at Carbide, Sargent has worked on various problems in handling acetylene, particularly stability and behavior on decomposition. Among the noteworthy accomplishments with which Sargent has been associated is the flame-plating process for making metal and ceramic coating which uses oxygen-acetylene detonations to heat and propel particles.

The University of Minnesota awarded Sargent his bachelor's in chemical engineering in 1935. Over the years, he has been active as a member of the American Chemical Society, American Rocket Society and Combustion Institute.

Whenever Sargent wants a change of pace, he collects native Indiana trees and shrubs; throws and fires stoneware jugs, pots and bowls.

PEOPLE . . .

LETTERS:

Any Unsolved Problems?

Sir:

All well-informed persons realize that unknown truths are probably as numerous as the known ones. But nobody has yet attempted to explore in detail what remains to be done in each and every area of knowledge. That is what Robert E. Pike and I propose to do.

Consequently, if any of your readers are aware of any significant problem in their own field which has up till now remained unsolved, or any important fact which has been somehow neglected, they are invited to take part in our survey, which will be published next year by the Philosophical Library. We mention as typical entries: That nobody knows the causes of cancer, that nobody has explained the physiology of sleep, that nobody has succeeded in proving that Joan of Arc was actually burned to death.

All contributions should be limited to 1,500 words, setting forth a mere exposition of the problem in question. Each author is asked to write so as to be understood by the general reader. A few bibliographical references are desirable. Our board of editors will read every article submitted, and each author will receive full credit.

Papers should be sent to the undersigned.

RALPH B. WINN
224 Cummings Ave.
Elberon, N. J.

Pro: 100 Octane Clear

Sir:

In your December Pictured Flowsheet on catalytic reforming (pp. 374-377) you included a footnote which stated that several processes, including Ultraforming, "can produce only about 95 clear octane gasolines in normal operation."

As regards Ultraforming, this statement is incorrect. We reported at the American Petroleum Institute meeting in Montreal last May that gasolines of

PRO & CON

C. H. CHILTON

better than 100 octane are produced in normal operation of the 21,200-bbl./day Ultraformer located at American Oil Co.'s refinery, Texas City, Tex. During the approximate eight months which have elapsed since this paper was presented, Ultraforming operations on this unit have averaged about 101 clear octane.

Commercial Ultraforming to octane levels greater than 95 clear is not limited to Texas City operations. The feasibility of Ultraforming to such octane levels has been demonstrated in several other commercial Ultraforming units operated by Standard Oil and its Ultraforming licensees.

ROBERT C. ARNOLD
Standard Oil Co. (Ind.)
Chicago, Ill.

Con: Wrong Numbers

Sir:

In going over the Directory of Construction Materials in your November issue we were pleased to find that Amercoat Corp. is listed on p. 200 as the manufacturer of epoxy and vinyl tank linings in sheet and liquid forms.

We discovered to our dismay, however, that under "Material Classification" on p. 199 we are not shown as a manufacturer of these materials. The material code numbers to which our products apply are 16.5 and 16.6.4.

F. J. DUNNE
Amercoat Corp.
South Gate, Calif.

▶*Inadvertently, code numbers for Aluminum Co. of America (No. 6) and Amercoat (No. 7) were switched in the section on classification of materials. Easiest way for our readers to rectify this mistake is to switch the two numbers in the left-hand column of p. 200 so that the listings on pp. 198-199 then refer to the proper manufacturers.*—ED.

Charts Look Alike

Sir:

"The Coming Nuclear Industry," by H. E. Anderson in your December issue (pp. 191-210),

features an industry flow chart on p. 191 which we developed and published in May 1955 as our Chemical Plants Reference File 9-3.11. We would appreciate your crediting Blaw-Knox Co. as the source of this material.

M. M. RAMER

Blaw-Knox Co.
Pittsburgh, Pa.

► *The strong resemblance between Blaw-Knox's chart and ours is not pure coincidence, as Mr. Ramer rightly concludes. We are glad to acknowledge the Blaw-Knox chart as one of the sources for our version.*—ED.

Titanium's Deficiencies

Sir:

In "Titanium Moves Into Process Equipment" (Dec. 1956, pp. 238-248), the statement on p. 248 that titanium can be "an excellent material for racks in anodizing, plating and electropolishing baths" should be qualified.

Titanium is not generally useful, like copper, brass and aluminum, but is specific and limited, like the nickel-chrome steels. It lacks electrical conductivity, possibly because of oxide formation, and its resistance to some common plating-room acid baths leaves much to be desired.

EARL J. MONTIE

Briggs & Stratton Corp.
Milwaukee, Wis.

Pro: Fire Protection Library

Sir:

Fire protection and prevention have always been stepchild sciences. Until now, not one public institution or association has set up a comprehensive fire protection library easily accessible to the general public.

The Brooklyn Public Library, Science and Industry Division, opened a fire protection collection in January. The Ingersoll Bldg., located at Grand Army Plaza, Brooklyn, is open seven days a week for research by chemical engineers, fire prevention specialists and all others interested in the field.

Manufacturers' catalogs, book and bulletins pertaining to such subjects as flammable liquids, fire retardants, foams, dusts and explosives would be most helpful

in building up this collection. Any assistance your readers may be able to render would be greatly appreciated.

SYLVIA MECHANIC
Brooklyn Public Library
Brooklyn, N. Y.

Accuracy vs. Convenience

Sir:

This is a belated comment on the article, "Liquid Densities Over Temperature Range," in your March 1956 issue (pp. 196-198).

I would like to call your attention to my correlation published in *Ind. Eng. Chem.*, Jan. 1949, p. 96. Fig. 1 therein is a plot of V_R vs. T_R, and shows five curves, since no one curve would fit all the experimental data.

The data required for use of this earlier correlation are the same as for Prof. Osburn's, and I believe that mine is fully as convenient to use. In addition, it is capable of greater accuracy by choosing the proper curve for the liquid in question.

EDWARD S. HANSON
Firestone Tire & Rubber Co.
Akron, Ohio

Sir:

I'm sorry that I failed to include Mr. Hanson's article in my list of references.

He is correct in claiming that his correlation is capable of greater accuracy than mine. However, to get greater accuracy one would have to replot his Fig. 1 to a larger scale.

I can't agree that his correlation is fully as convenient to use. It involves reading two values from a graph and making three numerical calculations; with my method you have only to draw two lines on the chart and read your answer.

JAMES O. OSBURN
State University of Iowa
Iowa City, Iowa

Pro: Enzymatic Processes

Please accept our appreciation concerning the article, "Fermentation Catalyzes Enzyme Business" (Nov. 1956, pp. 122-124).

We were particularly attracted by mention of an enzymatic process for the recovery of

silver from scrap photo film. Would it be possible to disclose the enzyme manufacturer?

G. A. Stodola
Industrial Research & Development Co.
Montreal, P. Q.

▶ *Proteolytic (protein-splitting) enzymes, such as commercial pepsin, help release silver from the gelatin emulsion of photo film. Takamine Laboratory, whose operations formed the basis for our story, claims to have a special, more specific enzyme to do this job.* —Ed.

Heavyweight Absorber

Sir:

In reading your October issue we are pleased to find on p. 116 an item about Allied Chemical & Dye's new nitric acid absorber tower which was fabricated by our company. We would appreciate your sending us three tear sheets for posting on employees' bulletin boards.

We would like to add that the weight of the absorber is 150,000 lb., not 15,000 lb.

E. Starke Farley
Richmond Engineering Co.
Richmond, Va.

Pro: Liberal Arts Colleges

Sir:

I have been greatly interested in the McGraw-Hill series of editorials about the relationship of industry and education.

Since I am chairman of the boards of trustees of both Hobart and William Smith Colleges, these editorials are music to my ears. I am sure they are helping to excite a greater positive interest on the part of industrial leaders in the need for helping universities and colleges.

There is one thought which I would like to put forth that perhaps McGraw-Hill might study. A number of large engineering and chemical firms appear to be far more interested in the technical universities—those which have strong chemistry and chemical engineering departments—than they are in the small liberal arts colleges. This, of course, is evidenced by the fact that most of their grants in scholarship and fellowship money are given to the bigger schools. To a large

extent, this is certainly understandable.

But we are overlooking one fact—that is, that a goodly number of men who hold advanced degrees took their basic work in small colleges. There they had not only specialized training in chemistry, let us say, but also had a fairly well rounded course of arts and letters. Many of these men were far better equipped to handle themselves in a small school, and got a great deal more out of their undergraduate work, than if they had gone to a large university and were lost in the shuffle.

In New York State, the Empire State Foundation is soliciting funds from industry for some 26 small colleges in the state. Each year industry is giving more and more to this foundation. The same sort of foundations are organized, or are being organized, in virtually all the larger industrialized states.

I am of the opinion that a strong case can be made for more financial aid to the small liberal arts colleges because of the important contributions they make to industry.

No doubt I am somewhat prejudiced on the side of the small liberal arts colleges. But just to give you an idea how the Ph. D. relationship works out here in our firm, only one-third of our Ph. D.'s took their undergraduate work in universities of over 2,500, and one-third of them went to schools under 1,000.

You are also aware that a number of small colleges have arrangements with large universities whereby three years at the small college and two years at the large university call for an A.B. degree from the small college and a B.S. degree from the university.

I had a long discussion with our research head yesterday on the matter of recruiting technical people, and the problem is becoming more acute from year to year. McGraw-Hill is taking a very sound, positive approach, and I am sure it is stirring up interest which will result in solutions to the problem of developing more trained personnel.

R. W. ALBRIGHT
Distillation Products Industries
Rochester, N. Y.

PEOPLE . . .

NAMES IN

Leonard Seglin

To fill the position of manager of engineering development for its new organic chemicals division, Food Machinery & Chemical has chosen Leonard Seglin.

After six years with Ethyl Corp., doing development work, Seglin joined Westvaco Chlorine Products' central engineering department. When Westvaco became a part of FMC, he took charge of economic evaluations for the development department of the Westvaco Mineral Products Division. Later, he became supervisor of processing engineering for the combined FMC Chemical Divisions.

Seglin is a native New Yorker and graduated in chemical engineering from NYU in 1938.

Harlan J. Lortz, a chemical engineer with a heavy background in research, has joined Amana Refrigeration, Inc., as a process engineer.

Reader G. Anderson has been promoted to assistant general superintendent of operations and utilities at the American Oil Co. refinery in Texas City, Tex.

Marshall Sittig, formerly of Ethyl Corp., has been elected president and managing director of American Lithium Institute, Inc.—newly formed research organization.

Eugene Allen has been named a group leader in the dyes re-

THE NEWS

M. A. GIBBONS

search section of the Bound Brook Laboratories of American Cyanamid.

W. L. Faith has been appointed managing director of the independent scientific research organization—Air Pollution Foundation. Faith has been the outfit's chief engineer since operations began in 1954.

G. L. Pitzer has been named vice president of production of Bakelite Co. Till now, he had held the post of works manager.

Chalmer Kirkbride

Sun Oil Co., Philadelphia, has named Chalmer G. Kirkbride as executive director of its research, patent, and engineering departments. In doing so, Kirkbride resigned as president and chairman of the board of Houdry Process Corp., Philadelphia.

A chemical engineering graduate of the University of Michigan, Kirkbride began his career in 1930 with Standard Oil (Ind.). Four years later, he became assistant director of research for Pan American Refining Corp. Then, in 1942, he joined Magnolia Petroleum Co. as chief of chemical engineering development.

Soon after, he spent three years as distinguished professor in chemical engineering at Texas A & M. He compiled the text "Chemical Engineering Fundamentals" (McGraw-Hill

Book Co.), from the basic course he taught there.

During the Bikini atom bomb tests, in 1946, Kirkbride served as a scientific consultant to the secretary of war.

In 1952, he was appointed president and chairman of the board of Houdry Process Corp. Three years ago he served as president of the AIChE.

Thornton F. Holder

Diamond Alkali Co., Cleveland, has named Thornton F. Holder to the post of director of research.

Holder will continue to be responsible for Diamond's patent and trade mark activities and for supervision of general-purpose research facilities and operations — otherwise unassigned.

When he first came to Diamond, Holder served as patent counsel. Eight years later, he was named research coordinator as well.

During the war, he had served in the U. S. Navy on special assignment to the wartime atomic energy program.

L. H. Betow has been promoted to the newly created position of assistant to **Harold G. Osborn,** senior vice president of Continental Oil Co., Houston, Tex.

W. D. Kohlins has been promoted to manager of the Buflovak Equipment division, Blaw-Knox Co. Kohlins' headquarters are in Buffalo, New York.

E. L. Demarest has been transferred from Blaw-Knox's Philadelphia office to Buffalo

as manager of sales. Before joining the firm, in 1948, Demarest had been associated with Heyden Chemical.

Donald H. Tilson, assistant manager of Alcoa's northwest operations at Vancouver, Wash., since last April, has been promoted to manager. He succeeds **C. S. Thayer** who retired recently.

Glenn H. Reinier has been elected president of the Chicago Drug & Chemical Ass'n. He is also director of purchasing for Abbott Laboratories.

Sidney L. Eastman, former chief engineer of the Cleveland Worm & Gear Co., is now VP in charge of engineering.

Oscar E. Clary, plant manager of Diamond Black Leaf's Richmond, Va., plant, will now fill a similar post in Louisville, Ky.

J. W. Angstadt has been named manager of engineering for the Buflovak Equipment division, Blaw-Knox Co. **H. A. Collins** is now acting manager of manufacturing.

Thomas H. Cox has been transferred from du Pont's Victoria, Tex., plant to the Belle Works, Charleston, W. Va., as assistant technical superintendent.

E. C. Sargent

New president of Zirconium Corp. of America is E. C. Sargent—former vice president and general manager of the firm.

A native of St. Paul, Minn., Sargent was, for some years,

project manager for the engineering division of Vitro Corp. of America. From 1949 to 1952, he served as Cleveland area manager for the AEC. Sargent is also founder and, currently, a director of Radiation Applications, Inc., New York consultants.

Sargent holds a bachelor of chemical engineering degree from Cornell University.

J. Henry Rushton

Professor of chemical engineering at Purdue University—J. Henry Rushton—has been elected this year's president of the American Institute of Chemical Engineers.

Rushton is well known in chemical engineering circles as a teacher, a consultant, and an active member of the AIChE. Before taking on the Purdue post, he was professor and head of the chemical engineering department at the University of Virginia for a decade and held a similar position at the Illinois Institute of Technology. As a consultant, he has served the Department of Defense, the AEC and various firms in the fields of petroleum and food.

Last year, he served as vice president of the AIChE and in 1952, the Institute presented him with the Wm. Walker award.

W. D. Kohlins has been named division manager of the Buflovak Equipment Division, Blaw-Knox Co., Buffalo.

Richard A. Glenn, research chemist, has been promoted to supervising chemist for Bituminous Coal Research, Inc., Pittsburgh.

H. W. Strong, Jr., has been appointed vice president in charge of operations of Colton Chemical Co., Cleveland.

George F. Reddish of St. Louis, Mo., has received the 1956 achievement award of the Chemical Specialties Manufacturers' Ass'n for his work in public health and disinfection.

Frank Elliott has been designated chairman of the board of directors of Crane Co. and will be succeeded as president of the firm by **Neele E. Stearns.**

J. H. Hill is now assistant superintendent of Carbide & Carbon's Seadrift, Tex., plant. He'll be succeeded by **O. D. O'Bryan** in his former position as area supervisor over the firm's number two olefin plant.

Benjamin M. Holt has been appointed to the newly-created post of project director of the planning and development department of American Potash & Chemical Corp.

James H. Wiegand has been appointed head of the newly formed solid engine research department of the solid rocket plant, Aerojet-General Corp., Sacramento, Calif.

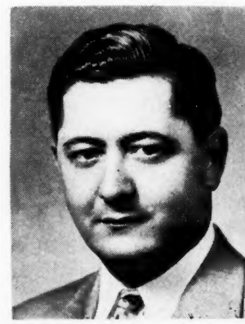
H. F. Robertson

Bakelite Co. has named H. F. Robertson its new manager of technical planning. The new position is designed to handle long-range research and development.

After graduating in chemical engineering from the University

of Toronto in 1923, he became a fellow at Mellon Institute, Pittsburgh. Robertson's first association with Union Carbide came, in 1926, when he was transferred to the chrome-ore fellowship sponsored by the firm at Mellon. For the next 13 years, he continued work on refractories, organic syntheses and plastics until 1939, when he joined Union Carbide in New York.

Most recently, he had been manager of the firm's new products engineering department.



William L. Rodich

General manager of General Electric's laminated products department, William L. Rodich, has been elected chairman of the laminated products section of the Nat'l Electrical Manufacturer's Ass'n.

Rodich is a graduate of Brooklyn Polytech with a degree in chemical engineering. Recently, he was one of 100 alumni to receive a certificate of achievement award from the Institute.

His office is located at GE's laminated products department headquarters in Coshocton, Ohio.

Chaplin Tyler, of du Pont's development department, was elected an alumni term member of Northeastern University Corp.

R. B. Strawn has succeeded **John P. Paca** as director of research of Diebold, Inc., Canton, Ohio.

Ralph P. Perkins will succeed **Edgar C. Britton** as director of Dow Chemical's organic re-

search lab in Midland, Mich. Britton will continue to serve as a research consultant for the entire firm.

Russell G. Dressler has resumed professional services as a chemical process consultant, with an office in San Antonio, Tex.

Odell Campbell, former manager of laboratories for du Pont in Tulsa, Okla., has joined Kerr-McGee Oil Industries, Inc., in Oklahoma City, Okla.

Frank E. Lawatsch has been named manager of the marine and oil processing division of the De Laval Separator Co.

Carroll H. Smith, Jr., has joined Ethyl Corporation's technical staff as a technical supervisor. Formerly, he was employed by Rocky Mt. Arsenal in Denver.

Frank P. Greenspan, former manager of organic research and development for Becco Chemical Div., has been named director of development for Food Machinery & Chemical's new organic chemical division.

Theodore Burtis

Houdry Process Corp., Philadelphia, has elected Theodore A. Burtis president and chairman of the board of directors. He'll also serve as a director of the firm's subsidiary, Catalytic Construction Co.

Burtis graduated from Carnegie Tech in 1942 with a degree in chemical engineering; some years later, he earned a master's at Texas A & M. After a

few years with Magnolia Petroleum and Owens-Corning Fiberglas, he joined Houdry as chief of the economics section, research and development division in 1947.

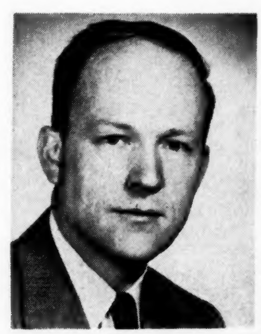
Most recently, he served the firm as associate manager of research and development at the Linwood, Pa., laboratories.

G. H. Gleason has been appointed manager of the Philadelphia office of The Foxboro Co., Foxboro, Mass.

Fred C. Young, manager of Ford Motor's chemical and metallurgical department, manufacturing staff, has been awarded a certificate of appreciation by the Society of Automotive Engineers for his work with their iron and steel technical committee.

Theodore Weaver, manager of process development for Fluor Corp., Ltd., Los Angeles, has won the 1956 Junior Award for the American Institute of Chemical Engineers for contributions to the Institute's publications.

Lester Woolfenden has been named plant manager of the acetylene chemical products plant of General Aniline & Film Corp., Calvert City, Ky.



Robert J. DeLargey

Resident manager of Food Machinery & Chemical's Westvaco Chlor-Alkali plant in So. Charleston, W. Va., has been promoted to the post of director of engineering for FMC's chemical divisions.

DeLargey will be responsible for major plant design and con-

struction, process development and industrial engineering activities for all chemical divisions.

He graduated from Case Institute of Technology in chemical engineering. Prior to his present assignment, DeLargey was division production manager and director of engineering for the Westvaco division.

Hugh F. Beeghly

Jones & Laughlin Steel Corp., Pittsburgh, has named Hugh F. Beeghly to the new position of research associate.

Beeghly, formerly section head, chemistry, for the firm's research and development department, will assume responsibility for applying developments in the nuclear energy field to the firm's processes and for applying J&L products to nuclear purposes.

A native of Brandonville, W. Va., Beeghly earned his degree in chemical engineering from the State University in 1936.

OBITUARIES

O. Harold Bratt, 45, chemical engineer for General Electric Co., died Nov. 28. Since he joined GE's Anaheim, Calif., chemical plant 10 years ago, he had worked in product development, design and sales capacities.

Hugh Christison, retired chief chemist of Arlington Mills, Lawrence, Mass., died Nov. 5 at his home in Methuen, Mass. Christison had been an honorary member of the American Ass'n of Textile Colorists as well as a vice president (1944-46).

PEOPLE . . .

FIRMS IN

NEW NAMES

DeZurik Shower Co. of Sartell, Minn., has changed its name to DeZurik Corp.

Sel-Rex Precious Metals, Inc., Newark, N. J., has changed its name to Sel-Rex Corp.

Nuclear Instrument & Chemical Corp., Chicago, has changed its name to Nuclear-Chicago Corp.

Hagan Corp., Pittsburgh, Pa., has changed its name to Hagan Chemicals & Controls, Inc.

NEW REPRESENTATIVES

Cellofilm Industries, Inc., Woodridge, N. J., producers of nitrocellulose base solutions, has appointed Baird Chemical Corp., New York, N. Y., as sales representatives.

Plax Corp., Hartford, Conn., has made a marketing agreement with Monsanto Chemical Co. whereby Monsanto will enlarge its present sales force to handle Plax's Polyflex sales in addition to its Plastic Div.'s present lines.

NEW FACILITIES

Warner-Lambert Pharmaceutical Co. has opened a new multi-million dollar plant in Lititz, Pa., to house its Lambert-Hudnut division.

General Electric Co. has signed a contract for the sale of a portion of its interests in the manufacture of alkyd resins to Archer-Daniels-Midland Co. of Minneapolis, Minn.

Anderson-Prichard Oil Corp., Oklahoma City, Okla., is constructing a 3000-bbl./day propane deasphalting unit to be completed late in 1957.

Vitro Corp. of America is purchasing Berkshire Chemicals,

Inc. of New York, chemical sales organization.

Commerce Oil Refining Corp. is building a $32-million oil plant at Jamestown, R. I.

Humble Oil & Refining Co. is constructing a benzene unit with a capacity of 24-million gal./yr. at its Baytown refinery.

Redel Inc., Anaheim, Calif., has added new facilities at 220 North Atchison St. for their general offices and chemical services division.

Martin Co.'s nuclear division, Baltimore, Md., has completed a 5,500 curie, cobalt-60 source of gamma radiation.

Timken Roller Bearing Co., Canton, Ohio, is constructing a $500,000 metallurgical research laboratory.

Texas City Refining Co. is installing a 7,000-bbl./day Houdriformer at its Texas City, Tex., refinery.

Standard Steel Corp., Los Angeles, Calif., has purchased Leader Iron Works of Decatur, Ill.

Pan-Am Southern Corp. is spending $2.7 million on construction of new facilities at its refinery in El Dorado, Tex.

Metal Hydrides, Inc. is building a hydrogen plant to produce hydrogen of 99.8% purity at its new facility at Danvers Mass.

Shell Development Co. is planning a $1-million expansion program for its Modesto, Calif., agricultural research center.

California Oil Co. has purchased Lincoln Oil Co. of Boston, Mass.

G. D. Searle & Co., Chicago, medical research and phar-

FIRMS . . .

maceutical manufacturing organization, has announced expansion of its facilities in Great Britain to provide for increased production of pharmaceuticals to serve overseas markets.

Johns-Manville Corp. is expanding its Dutch Brand Div. plant in Chicago by approximately 50%.

Texas-U.S Chemical Co. has purchased property in Parsippany-Troy Hills Township of Morristown, N. J., for the construction of a research center.

Speer Carbon Co. is constructing a new research and development laboratory in Niagara Falls, N. Y.

Pennsylvania Salt Mfg. Co., Philadelphia, Pa., is acquiring Delco Chemicals, Inc.

Portland Cement Association is constructing two new laboratory buildings estimated to cost about $2.75 million at its Research and Development Laboratories in Skokie, Ill.

Airetool Mfg. Co., Springfield, Ohio, is constructing a new manufacturing plant in Brantford, Ont., to serve the needs of its Canadian clients.

Lima Rubber Co., Lima, Peru, a company associated with B. F. Goodrich Co., will begin production early in 1957 in a new tire plant.

Metal & Thermit-United Chromium of Canada, Ltd., has completed construction of a new combined office, warehouse and manufacturing facility in Etobicoke Township, Toronto.

Monsanto Chemical Co. is working on a river barge terminal at the Krummrich plant, in Monsanto, Ill., to be used for the receiving of sulfur.

Gulf Oil Corp. has acquired options to purchase over 3,000 acres of land near Charleston, S. C. The company is in-

vestigating the site to determine whether it might make a satisfactory location for a new refinery at some future date.

Borg-Warner Corp. is constructing a new plant in Auburn, Ind., to house the Warner Automotive Parts Div.

Ohio Oil Co., is planning to construct a common carrier product pipeline, with an ultimate capacity of 90,000 to 100,000 bbl./day, from Wood River, Ill., to Chicago.

Atlantic Research Corp. will start construction early in 1957 of new million-dollar offices and research laboratories in Virginia, less than eight miles from Washington, D. C.

American Oil Co. is constructing a second 21,000-bbl./day Ultraformer at its refinery in Texas City, Tex.

Carbide & Carbon Chemicals Co. has announced plans for construction of a new multimillion dollar engineering building in South Charleston, W. Va.

Foote Mineral Co. has purchased ceramic grinding facilities at Cold River, N. H.

Eagle-Picher Co., Cincinnati, Ohio. has purchased Chicago Vitreous Corp. and Lusterlite Corp., an affiliate, both in Cicero, Ill.

Armour Research Foundation of Illinois Institute of Technology, Chicago, has created a new combustion laboratory.

Tidewater Oil Co. has placed in operation three large petroleum processing plants at its Delaware Flying A Refinery.

Anthony Co., Streator, Ill., has purchased Truck Crane, Inc., Chicago, Ill.

Trane Co., La Crosse, Wis., is installing a new compressor production line, increasing

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present capacity by over 100%.

Arner Co., Buffalo, N. Y., in cooperation with the University of Buffalo, has established a training center for top chemistry students interested in learning pharmacy drug manufacturing.

Olin Mathieson Chemical Corp. has ordered three specially designed tank barges to expand facilities for shipping liquid chlorine along the Gulf of Mexico and between industrial chemicals division facilities at McIntosh, Ala. and Brunswick, Ga.

Western Plywood (Alberta) Ltd. Edmonton mill has officially opened. The plant has the capacity to produce 3,000 plywood panels/day.

W. P. Fuller & Co. is constructing warehouse and office facilities at a cost of $500,000 in Anchorage, Alaska.

Coastal Chemical Corp. will start construction in April on a $2-million phosphate fertilizer plant in Pascagoula, Miss.

Pacific Coast Transport Co. will operate the tankship fleet of Union Oil Co. of Calif.

Consolidated Electrodynamics Corp. has purchased R. A. Castell & Co., Glendale, Calif., electronic components manufacturer.

Crown Zellerbach Corp., San Francisco, has optioned 187 acres of ocean front property near Ventura, Calif., as a prospective site for a paper mill.

Arthur D. Little, Inc., Cambridge, Mass., has expanded its activities into the high-temperature field and is completing a solar furnace for such research.

American Smelting & Refining Co. has announced that the company's Federated Metals Div. will begin construction of a large secondary alumi-

num plant at Alton, Ill., to double Federated's present aluminum production.

Metal & Thermit Corp. has purchased a 163-acre site near Carrollton, Ky., and will soon begin construction of a new chemical processing plant.

Witco Chemical Co. has acquired Ultra Chemical Works, Inc. of Paterson, N. J.

Parke, Davis & Co. has selected a site in Ann Arbor, Mich., for its new $10-million medical research center.

Clark Oil & Refining Corp. has completed construction of 19 storage tanks which have doubled the storage capacity of the company's Chicago refinery.

Resin Research Laboratories, Inc., is building a new resin research center at 400 Adams St., Newark, N. J.

Ferro Corp.'s Fiber Glass Div. has completed a $1.5-million expansion program at the Nashville, Tenn. and Huntington Beach, Calif. plants.

Ammonia Chemical Corp. of California plans to construct a $5-million anhydrous ammonia plant near Huron, Calif.

Cities Service Co. plans to build a 20,000-bbl./day refinery in the Toronto area and spend some $8 million on construction of bulk plants, service stations and other marketing facilities in provinces of Ont. and Quebec.

Air Products, Inc., Allentown, Pa., has acquired Steele Gases, Inc., Chicago.

Fuji Cement Co.'s new mill at Muroran on the island of Hokkaido has recently put into operation Japan's first closed circuit grinding wet process cement plant.

Japanese Geon Co., Ltd., of Tokyo, as associate company of B. F. Goodrich Chemical Co., Cleveland, Ohio, has be-

FIRMS . . .

gun production of polyvinyl chloride at its new plant at Takaoka.

Continental Uranium, Inc., Chicago, has acquired three building supply companies, Transit-Mix Concrete Co. and Daniels Sand Corp., Colorado Springs, Colo., and Pacific Materials Corp., St. Louis, Mo.

Universal Match Corp. has acquired Dynamics Research Associates, Seattle engineering group.

Kaiser Aluminum & Chemical Corp. has leased the extrusion plant of Hokin Aluminum Co. in Dolton, Ill., to speed up by two years its midwest extrusion expansion program.

International Business Machines Corp. and the University of California at Los Angeles have established the world's first university computer center devoted to the study of complicated business management problems. The Western Data Processing Center will be located on the UCLA campus.

Baldwin-Hill Co., Trenton, N. J., has acquired the Wabash, Ind., plant of the Eagle-Picher Co. which manufactures basic mineral wool products.

New Jersey Zinc Co. has a new mill in Jefferson City, Tenn., with a capacity of 1,000 tons/day.

American Zinc Co. has borrowed $384,000 from the federal government for zinc exploration in Knox and Jefferson counties, Tenn.

Proctor & Gamble Co. has new headquarters at Sixth and Sycamore Sts., Cincinnati, Ohio.

Plough, Inc. has acquired Oliver Tablet Co. of Columbus, Ohio.

Argonne National Laboratory, Lemont, Ill., operated for the

U. S. Atomic Energy Commission by the University of Chicago, is building Experimental Breeder Reactor II.

Sylvania Electric Products Inc. and Corning Glass Works are forming a jointly-owned Delaware company, Sylvania-Corning Nuclear Corp., for the purpose of expanded research, development, and production activities in the atomic energy field.

General Electric Co.'s Atomic Power Equipment Department is constructing a new facility to develop and prove procedures and equipment for refueling large boiling water reactors.

Reynolds Metals Co. is investigating Pacific Northwest sites for an aluminum fabricating plant.

Dow Chemical Co. has placed in operation its new $1-million styrene-butadiene latex plant at Pittsburg, Calif.

Koppers Co. will build a full-scale commercial plant for the production of expandable polystyrene beads at its Kobuta, Pa., operation.

Schering Corp., pharmaceutical manufacturer, has nearly completed its $1.5-million biological research building in Union, N. J.

Kish Industries of Lansing, Mich., has purchased Trenton Chemical Co., Trenton, Mich.

Factory Mutual Laboratories, Norwood, Mass., has announced that its facilities are now available on a contract basis to organizations seeking help in product development or other research.

Link-Belt Co. will build a new plant in Montebello, Calif., to replace and expand its facilities in Los Angeles. The expected completion date is late-1957.

Paul Hardeman, Inc. has announced the merger of its various subsidiary companies.

The companies involved are: J. B. Gill Co., Wall Cryogenics, Inc., Climate Conditioning Corp., Systems Engineering Co., and Electronetics Corp.

National Gypsum Co. has begun its $19-million Great Lakes area expansion program involving construction of two gypsum building products plants and development of a northern Michigan gypsum deposit.

NEW LOCATIONS

International Minerals & Chemical Corp. has moved to 485 Lexington Ave., New York 17, N. Y.

Geigy Chemical Corp. has moved to Saw Mill River Road, Ardsley, N. Y.

Foster Grant Co. has announced that a portion of its new nylon plastics manufacturing operation will be established in Lamex Chemical Corp.'s plant in Manchester, N. H.

NEW LINES

Kaiser Gypsum Co. has entered the insulation board market through the purchase of Fir-Tex Insulation Board, Inc.

Flexonics Corp., Maywood, Ill., has acquired the Flex-O-Tube Div. of Meridan Corp., Inkster, Mich., to provide industry with one line of flexible hose and fittings of all materials for industrial use.

Marken Plastics Corp., Los Angeles, has entered the plastic pipe industry with a full line of both rigid (PVC) and flexible (polyethylene) pipe and tubing.

B. A.-Shawinigan Ltd. will commence production of hexylene glycol at its plant at Montreal East, Canada, in March, 1957.

NEW COMPANIES

Brown Thermal Development Co. has been formed as a new subsidiary of Brown Fintube Co., Elyria, Ohio, to develop,

design, manufacture and sell heat transfer equipment for waste heat recovery, recuperation, and air and gas heating by direct fire.

Anglo-Great Lakes Corp. Ltd. has been organized by Great Lakes Carbon Corp., New York, N. Y., for the production in England of nuclear and commercial graphite.

Upjohn Co. (Australia) Pty. Ltd., has been established as a new subsidiary in Australia by Upjohn Co., Kalamazoo, Mich., one of the nation's leading pharmaceutical manufacturers.

General Adhesives Co. has been formed by General Shoe Corp. of Nashville, Tenn., to handle its industrial adhesive business.

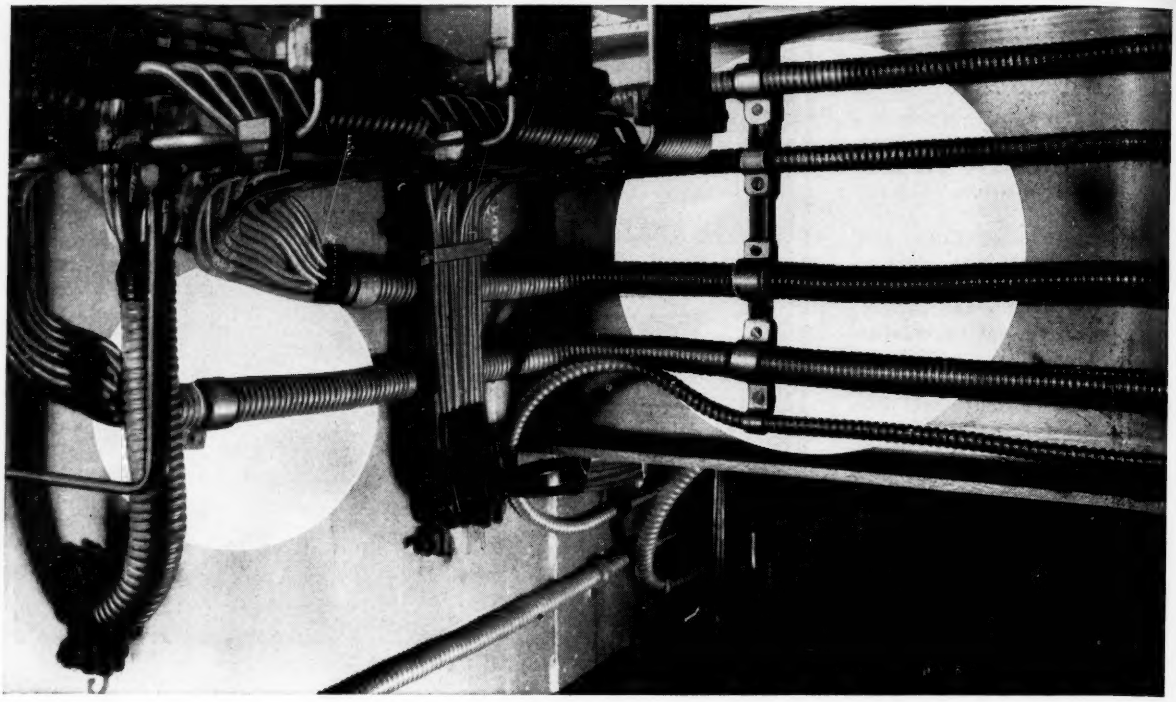
Yawata Chemical Industry Co., Ltd., Tokyo, Japan, has been created out of the chemical department of the Yawata Iron & Steel Co. and established as a separate enterprise.

George Fry & Associates International, Ltd., has been formed by George Fry & Associates, New York, N. Y., to render worldwide management consulting services to Canadian, European, Middle Eastern, and Far Eastern business and industry.

Union Carbide Research Institute near Tarrytown, N. Y., has been formed by Union Carbide & Carbon Corp. to engage in basic scientific research.

Standard Oil Co. of California, Western Operations, Inc., has been formed by Standard Oil Co. of California to manage petroleum operations in the West.

Homestake Sabre-Pinon Partners has been organized by Sabre-Pinon Uranium Corp. and Homestake Mining Co. Homestake, veteran San Francisco mining firm (gold, uranium), will have complete control.



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Chemicals

Acids, Fatty......These fatty acids are readily available from the El Dorado Div.—caprylic, eldhyco, capric, lauric, coconut, palmitic and myristic. Company makes complete details available and offers samples.
L456a *Foremost Food and Chem. Co.

Additives, Lubricant......Bulletin explains Moly-Sulfide's function as a lubricant additive and describes commercial uses, such as, chassis grease, railroad journal grease, heavy duty machine grease, etc. Bul. Lu-6.
416A Climax Molybdenum Co.

Alcohol, Furfuryl......Derived from agricultural residues & useful in manufacture of wide variety of products including resinous mortars, cements, binder resins, etc. Data on properties & uses in Bulletin 205.
334 *Quaker Oats Co.

Aldehydes......Bulletin presents aldehydes for chemical syntheses, rubber accelerators and synthetic resins. Gives physical properties, shipping data, constant-boiling mixtures, specifications, etc. See Bulletin F-5278C.
416B Carbide & Carbon Chem.

Amines, Primary......Booklet describing tertiary-alkyl primary amines gives physical and chemical properties and chemical reactions for t-butylamine, t-octylamine, Primene 81-R and Primene JM-T. Bul. SP-33.
416C Rohm & Haas Co.

Butyl Oleate......Witco butyl oleate has been found to be the best and most economical plasticizer for use in Neoprene Type WRT. Includes complete information on properties in Technical Service Bulletin No E-9.
416D Witco Chem. Co.

Calcium Chloride......Two bulletins offer tables, graphs, applications. Cover properties, use, and control of straight calcium chloride as brine medium in refrigeration and ice manufacturing systems. Bulletins 4 & 16.
181e *Solvay Process Div.

* From advertisement, this issue

LITERATURE

C. J. ROHRBACH

Carbon, Activated......New bulletin tells how to treat liquid waste with Adsorbit activated carbon to remove all types of organic impurities, and many organic materials. Full details made available in Bulletin J-30.
417A Barnebey-Cheney Co.

Caseins......Bulletin gives specifications covering these Caseins: ecco blend (Canadian and Domestic), standard (Domestic), supreme (Domestic), extra quality (Argentine), super G (Domestic). See Bulletin 26-55-1-7-56.
417B Harwick Standard Chem. Co.

Catalysts, Ion Exchange......12 p. booklet describes advantages of using ion exchangers as catalysts for epoxidation of unsaturated oils and olefins, hydration of ethylene oxide, esterification of alcohols. See Bulletin.
417C Permutit Co.

Catalysts, Platinum......Baker-developed platinum metal catalysts are available promptly, in any required concentration of metal—on the carrier an in the form best suited to your requirements. Request details.
125 *Baker & Co.

Chemicals......File folder contains availability charts of Baker light metal compounds, heavy metal compounds, acid (inorganic, organic, acid anhydrides) and complete price schedules. Available upon request.
44-5 *J. T. Baker Chem. Co.

Chemicals......Quick and easy reference contains latest physical property and condensed application data for more than 335 organic chemicals. 1957 edition features 21 new chemicals. Request Bulletin No. F-6136.
177 Carbide & Carbon Chem. Co.

Chemicals......New bulletin lists over 200 fine chemicals, intermediates and industrial chemicals. Includes chemicals for the dyestuff, textile, plastic, paint, metals, rubber, chemical and paper industries.
417D Aceto Chemical Co.

* From advertisement, this issue

Contents of this issue...

LITERATURE . . .

Chemicals . . . . "Products" Bulletin covers: vinyl monomers, tertiary acetylenic alcohols, ditertiary acetylenic glycols, ditertiary saturated glycols, substituted acetylenes and surfynols. Available upon request.
418A Air Reduction Chem. Co.

Chemicals. . . . . .New edition of Dow's general product catalog contains more than 375 basic industrial, agricultural and pharmaceutical chemicals. Includes descriptive information on principal product groups.
418B Dow Chemical Co.

Chemicals, Fine & Industrial. . . . . .Company offers latest comprehensive price schedule for fine and industrial chemicals. Also includes a price schedule for electronic chemicals, definition of grades & F.O.B. points.
418C J. T. Baker Chem. Co.

Chemicals, Organic, Synthetic. . . . . .Thirteenth edition of "Synthetic Organic Chemicals" presents properties, specifications, and uses of many products sold by Carbide. Handy manual on industrial organic chemistry.
418D Carbide & Carbon Chem.

Chlorine. . . . . .Offers valuable technical bulletins: #7—"Liquid Chlorine"; #8—"Alkalies & Chlorine in Treatment of Municipal & Industrial Water"; #11—"Water Analysis"; #14—"Chlorine Bleach Solutions."
181a *Solvay Process Div.

Chlorine, Liquid. . . . . .Presents new 72 p. technical and engineering service bulletin, "The Analysis of Liquid Chlorine and Bleach.' Literature contains valuable data, tables, charts and indexes. Bulletin No. 12.
181b *Solvay Process Div.

Curing Agents, Epoxy Resin. . . . . .Company offers curing agents: diethylene triamine, triethylene tetramine, dimethylamino propylamine, diethylamino propylamine and a alphamethylbenzyl dimethylamine. Bul. F-8665.
418E Carbide & Carbon Chem.

Defoamers, Silicone . . . . . . Dow Corning "Antifoam B" disperses immediately in aqueous solutions. No stirring or agitation required. Ready to use & ideal for continuous processing. Request particulars and free sample.
L457 *Dow Corning Corp.

Dimethyl Hydantoin. . . . . .4 p. bulletin gives physical properties and chemical reactions of DMH. Dimethyl Hyantoin (Acetonyl Urea) is now being produced on a tonnage basis. Bulletin is available upon request.
418F Glyco Products Co.

Elastomers. . . . . .Neoprene and Hypalon elastomers are used in improving products and cutting maintenance and replacement costs. Full details made available in free publication. "The Du Pont Elastomers."
105 *E. I. du Pont de Nemours.

Emulsions, Polyvinyl Acetate. . . . . .New bulletin describes methods of shipment, storage tanks, piping and valves, pumps and installation costs of polyvinyl acetate emulsions. Details in Bulletin PVB No. 522.
418G Colton Chemical Co.

Esters, Methyl. . . . . .These methyl esters are readily available from the El Dorado Div.—caprylate, Eldo 18, caprate, laurate, coconate, myristate, caproate, palmitate. Company makes details available and offers samples.
L456b *Foremost Food & Chem. Co.

Fluorides. . . . . .Harshaw fluorides serve many industries advantageously. Their top ranking is the result of rigidly controlled uniformity and quality. Request Harshaw's 40 p. book on hydrofluoric acid anhydrous.
114 *Harshaw Chemical Co.

Hydrolubes. . . . . .Advantages of Ucon Hydrolubes are: corrosion resistance, wear resistance, fire resistance, no effect on packings or seals, shear stability, low leakage losses, safe to handle, etc. Bulletin F-40134.
418H Carbide & Carbon Chem.

* From advertisement, this issue

Inhibitors, Chemical......Nalco 889, new chemical inhibiter, reportedly cuts corrosion rates 94% or more by forming a tough, corrosion-resistant protective film on metal surfaces. Details in technical data sheet.
419A National Aluminate Corp.

Isotopes......Company announces availability of literature describing in detail their services and facilities. Isotope measurement, fall-out studies, and radiocarbon dating are some of the services made available.
419B Isotope Products.

Ketones......Bulletin discusses ketones and covers: physical properties, constant boiling mixtures, shipping data, specifications and test methods and storage and handling. Bulletin made available upon request.
419C Carbide & Carbon Chem.

Lithium Aluminum Hydride......A specific agent for numerous organic reductions. Reference gives composition, properties, solubility, applications, typical reductions, handling, safety & storage data. Bul. 401-D.
419D Metal Hydrides.

Lithium Metal Dispersions ...... Data Sheets describe methods for laboratory preparation of lithium metal dispersions in such dispersing mediums as mineral oil, petroleum and wax. Available on request.
76 *Lithium Corp. of America.

Methylene Chloride......Booklet shows advantages methylene chloride offers for use as an aerosol pressure depressant, vapor degreasing solvent, cold cleaning solvent, extraction solvent and secondary refrigerant.
419E Dow Chemical Co.

Molybdic Oxide.......Presents detailed references, "Properties of Molybdic Oxide'—a review of the more important physical and chemical properties of this compound. Request your copy of Bulletin Cbd-1.
419F Climax Molybdenum Co.

Monomers, Acrylic......Technical notes on dimethylaminoethyl methacrylate list physical properties, toxicity, presence of an inhibitor, polymerization and quaternization of the monomer. Full details in Form No. 20B.
419G Rohm & Haas Co.

Oxides, Ethylene......Manual brings up to date the available information on analytical procedures, physical and chemical properties and industrial uses of ethylene oxide. Full details made available in Bulletin 1956.
419H Jefferson Chemical Co.

Picoline......Bulletin presents physical properties (net container contents pounds and typical analysis) and applications (pharmaceutical intermediates, monomer production, as a complexing agent). Bulletin F-40113.
419I Carbide & Carbon Chem.

Plasticizers......Bulletin covers company's line of plasticizers, the Polycizers. Will help you choose the proper plasticizer, or blends of plastizers, to formulate a high quality product. Bulletin 07-75-2-10-56.
419J Harwick Standard Chem. Co.

Plasticizers......Technical Service Bulletin gives test recipe used & physical test data for Witco #20, a plasticizer for natural rubber tread stocks. Has Mooney Scorch time 25% longer than the Pine Tar recipe. Bulletin R-12.
419K Witco Chem. Co.

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LITERATURE . . .

Plastics......1957 Condensed Reference File covers; polyethylenes, styrenes, vinyls, epoxies, phenolics and polyesters. Presents characteristics, fabricating techniques and major fields of application.
420A Bakelite Co.

Plating, Nickel......If you use, or fabricate, heavy industrial equipment where product contamination is a problem, you can probably use CF&I Lectro-Clad to good advantage. Lectro-Clad Technical Manual.
280-1 *Wickwire Spencer Steel Div.

Polyphenyl, Chlorinated......Aroclor 1248 is a highly stable chlorinated polyphenyl; does not support combustion up to its boiling range 652° to 725°F.; is non-corrosive. Request technical information.
95a *Monsanto Chem. Co.

Potassium Borohydride ...... Detailed reference gives composition, properties, solubility, applications, typical reductions, handling, safety and storage information. Request copy of Technical Bulletin No. 301-B.
420B Metal Hydrides

Reagents......Price Catalog No. 56 provides current prices for all Baker laboratory chemicals and specifications for new items. Specifications show the minimum standards of purity. Available upon request.
420C J. T. Baker Chem. Co.

Resins, Coumarone Indene......Bulletin presents a list of the grades the company has to offer, as well as their respective melting points, color, specific gravity, and physical form. See Bulletin 12-64-6-8-56.
420D Harwick Standard Chem. Co.

Soda, Caustic......Technical & engineering service bulletins cover a wide scope of subjects. Includes: physical & chemical properties, use, handling & storage of caustic soda, soda ash. Bulletin Nos 5 & 6.
181c *Solvay Process Div.

Sodium Borohydride.......MH sodium borohydride, $MaBH_4$ will reduce esters, acids, acid anhydrides, and acid halides. Announces the availability of detailed Bulletin 502-F and typical reduction procedure.
420E Metal Hydrides.

Sodium Hydride......Makes available a detailed technical reference containing information on: composition; properties; solubility; applications; typical reductions; handling; safety; storage. Tech. Bulletin 507-C.
420F Metal Hydrides.

Sodium Hydride Oil Dispersion......Detailed reference contains information on composition, properties, solubility, applications, typical reductions, handling, safety and storage. Request Technical Bulletin No. 508-A.
420G Metal Hydrides.

Sodium Hydrosulphite......New data sheet describes improved Vatrolite, a specially concentrated, granular form of sodium hydrosulphite. Applications in the textile industry for vat dyeing and color stripping.
420H Royce Chemical Co.

Sodium Lignosulfonates ...... "Polyfon Technical Bulletin Number 303" describes use of sodium lignosulfonates as binder for structural clay products. Describes 5 grades, their surface activity, wet & dry strength, etc.
420I West Virginia Pulp & Paper.

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Sodium m-Silicate......Valuable data on Drymet anhydrous—the most highly concentrated form of sodium m-silicate. Drymet File Folder contains technical data and suggested formulations. Request your copy.
B443 *Cowles Chem. Co.

Surface Active Agents......Valuable 40 p. catalog describes Tergitol surface active agents, nonionic & anionic. Includes general properties, applications, physiological properties, performance data, etc. Catalog F-5900D.
421A Carbide & Carbon Chem.

Tetrapotassium Pyrophosphate......New bulletin covers: description, typical analysis, properties, rate of solution and uses. This is a completely revised and expanded publication. Request Bulletin No. 505 2R.
421B Westvaco Mineral Products.

Construction Materials

Alloys, Hard-Facing......Hard-facing alloys in coils for fast, economical protection through mechanized deposition. Available in drawn tube wire form for trouble-free feeding. Request Bulletin F-30030.
421C Haynes Stellite Co.

Alumina......Of many electrochemically refined materials produced by company, Alundum fused alpha alumina is one of the most useful. Request "Norton Refractory Grain—Electrochemically Refined."
83 *Norton Co.

Castings, High Alloy......High alloy castings to your order . . . large, small, special shapes, corrosion resistant, heat resistant and abrasion resistant. The melt, casting and finishing are all carefully controlled and quality tested. See Bulletin No. 3354-G.
424 *Duraloy Co.

Cements......Bulletin describes Crystolon cement . . . a fine-grained silicon carbide cement, sized 30 mesh and finer, with the addition of an air-setting constituent. Complete details in Bulletin CP7.4.
421D Norton Co.

Coatings, Protective......Bulletin describes how good structural design aids coatings in protecting steel surfaces. Tells how to weld, rivet & use structural materials to avoid creation of corrosion problem areas.
297 *Amercoat Corp.

Coatings, Protective......Announces release of new Carbomastic series of protective coatings . . . epoxy-tar coatings with solids content ranging from 85% to 90% and applying at thicknesses up to 10 mils/coat. Bul. 803.
421E Carboline Co.

Coatings, Protective......Bulletin covers: function, composition, properties, consistency, products to use with, application, and advantages. Full details made available in Product Bulletin 13-116-2-9-56.
421F Harwick Standard Chem. Co.

Columns......Company designs and builds columns for fractionation, stripping, absorption, extraction, chemical reactions and other allied operations. Company makes full details available in Bulletin No. 940.
421G Pfaudler Co.

Fabrication, Welded......New 20 p. booklet, "Wonders of Welded Fabrication," tells dramatic stories of modern steel plate fabrication. Shows welded fabrication as indispensable to almost all basic industries.
421H Acme Welding Div.

Fastenings......New 24 p., semi-technical Flo-Form brochure presents valuable information and cost-saving ideas on corrosion-resistant fastenings. Complete details available in Form No. 613 Flo-Form Brochure.
421I H. M. Harper Co.

*From advertisement, this issue.

LITERATURE . . .

Fibers, Polyester......New type industrial fire hose jacketed with 100% Dacron offers these advantages: lightweight, abrasion-resistant, resistant to many chemicals, weather- and mildew-resistant. Booklet and details.
211 *E. I. du Pont de Nemours.

Films, Polyester......6 p. brochure describes the new "Scotchpak" brand heat-sealable polyester film. Emphasizes the heavy duty packaging and protective wrapping abilities of the heat-sealable film.
422A Minnesota Mining & Mfg. Co.

Metals, Talide......A tungsten carbide of superior quantity, is harder, stronger, and more resistant to abrasion than any other metal. Superior where wear, heat and strain are destructive. Catalog 56-G.
86 *Metal Carbide Corp.

Plastics, Molded.......Company offers new manual on molded plastics for automotive, electrical, appliance and industrial applications. Discusses the advantages and gives case histories of applications.
422B Richardson Co.

Refractories......Carborundum has pioneered scores of super refractories with a wide variety of properties to meet your most demanding requirements. For complete details, request new "Refractories" magazine.
223 *Carborundum Co.

Refractories ...... "Better Refractories Through Quality Control" describes the methods by which Harbison-Walker insures dependable uniformity of all refractory products. Bulletin available upon request.
422C Harbison-Walker Refractories.

Refractories......New catalog covers 19 standard brands of Remmey refractory brick. These refractories find application in the following industries: steel, ceramics, glass, cement, brick and clay, etc. Bulletin RB-20.
422D Richard C. Remmey Sons Co.

Rods, Filler......Company announces release of a new bulletin describing Ampco-Braz #3, which is a new, high-strength manganese bronze filler rod of uniformly high quality for oxyacetylene welding. Bul. 56L-171.
422E Ampco Metal.

Rubber......Company offers new 26 p. booklet about Ameripol rubber containing information about its physical properties and processing. Contains charts which analyze the properties. Request your copy.
422F Goodrich-Gulf Chemicals.

Rubber Parts......New 16 p. brochure describes the rubber-parts-making facilities and operations of the Industrial Rubber Products Div. of Oliver Tire & Rubber Co. Copies available upon request.
422G Oliver Tire & Rubber Co.

Rubber & Plastic Material......Piping, pumps, valves and tanks have a wide range of temperatures, pressure, impact resistance. For details about Ace rubber and plastic materials, request Technical Data CE-50.
315a *American Hard Rubber Co.

Steels, Stainless......40 p. bulletin presents useful engineering and fabricating data, including practical examples showing where, when and how stainless steel improves design, etc. "Stainles Steel in Product Design."
130 *Allegheny Ludlum Steel Corp.

Steels, Stainless......Wide selection assures you of getting the best stainless for every application. Extra care in storage, handling and shipping guards the quality of stainless stocks. Request Buyers Guide.
234 Joseph T. Ryerson & Son.

Tantalum......Company offers a corrosion test kit, available without charge to research technicians. Contains both tantalum sheet and wire. Also offers publication, "Corrosionomics," containing articles on tantalum.
432 *Fansteel Metallurgical Corp.

* From advertisement, this issue.

Electrical & Mechanical

Batteries......"Compact Power by Yardney" includes data sheets giving physical and electrical specifications of available cells and batteries—from a fraction of an ampere hour to thousands of ampere hours.
423A Yardney Electric Corp.

Bearings-Bushings-Washers...... Chempro's new Style FM-4 bearings, bushings, washers, etc., give service in pumps, mixers and reactors operating under highly corrosive conditions. Complete details in Bulletin CP554.
L453 *Chemical & Power Products.

Bearings, Roller......Bulletin covers load ratings, dimensions and other data on Dodge-Timken and SC and SCM ball bearings. Company makes complete details available in Bulletin A638. Request your copy.
313b *Dodge Mfg. Corp.

Belts, V......Bulletin covers construction details and data on sizes, pitch lengths and outside lengths. Company makes complete information available in Product Bulletin A-606. Request your copy.
313c *Dodge Mfg. Corp.

Clutches......Company offers new 76 p. manual on automatic freewheeling clutches; combination clutch-couplings; backstops to prevent reversed runaway of inclined conveyors or vertical elevators, etc.
423B Marland One-Way Clutch Co.

Gaskets, Teflon......Teflon FreeFlow gaskets are impervious to practically every chemical or gas and are unaffected by temperatures from -100° to +482°F, depending on the insert material. "The Best in Teflon."
329 *Crane Packing Co.

Illuminators, Gage......Jerguson gage illuminator gives up to 3 times the illumination . . . lights entire gage glass, no glare or blind spots, low cost lighting, exposion-proof. Full details in Data Unit.
R447 *Jerguson Gage & Valve Co.

Lighting Equipment, Fluorescent...... New 36 p. bulletin contains descriptions, illustrations and lighting data on 394 Benjamin industrial fluorescent lighting units. Company makes bulletin B available upon request.
423C Benjamin Electric Mfg. Co.

Magnets, Permanent......Introduction to catalog gives analysis of permanent magnetic properties and importance of engineered applications. Remainder of book features drawings and charts. See Catalog 156.
423D Magni-Power Co.

Motors......L. A, enclosed and explosion-proof motors feature: split conduit box, inner bearing cartridges, non-sparking fan, cast-iron end bracket and housing, prewound stator, locked bearings. See Bulletin 1700.
122 *Louis Allis Co.

*From advertisement, this issue.

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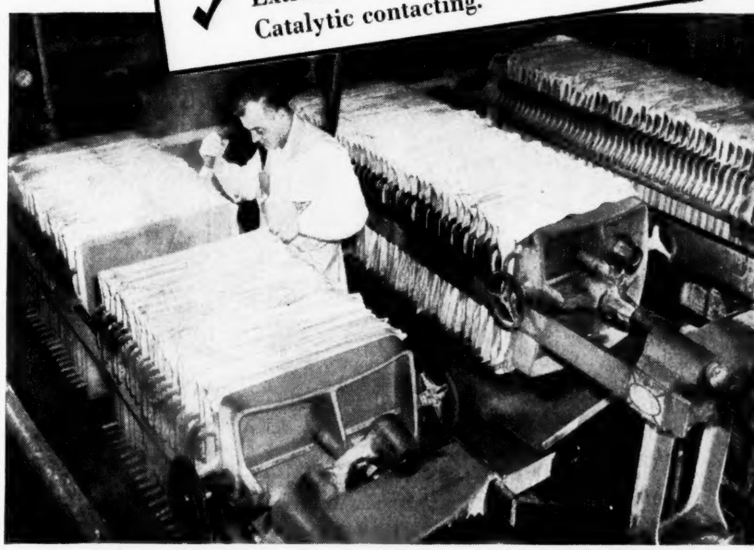

Motors......Over 2500 different types of fractional hp motors have so far been designed for specific use in business machines, aircraft equipment, electronic controls, automation systems, etc. Bulletin.
424A R. A. Boehm Co.

Motors......Bulletins describe open type or totally enclosed motors featuring: more power in less space, corrosion resistant frames, needed protection, cooler operation, longer bearing life. See Bulletins MU-202 and MU-203.
120 *Wagner Electric Co.

Motors, Chemical......Bulletin describes construction features of Allis-Chalmers totally-enclosed, fan-cooled and explosion-proof chemical motors 1 to 100 hp (Types GZ, GZZ, AZ, AZZ, APZ, APZZ). Bulletin 51B8477.
424B Allis-Chalmers Mfg. Co.

Motors, Synduction......Provide dependable constant speed, simplicity of operation and low first cost in a variety of industrial applications requiring 40 hp and below. Complete details available in Bulletin 51B8440.
117 *Allis-Chalmers Mfg. Co.

Motors, Vertical......Company offers information describing a newly designed vertical solid shaft motor, conforming to dimensional standards recently adopted by NEMA. Describes operation, features, etc.
424C U. S. Elecl. Motors.

Packings......Unique construction of Garlock Chevron permits free operation of rods or plungers at all pressures. Once you make initial adjustment of the gland, no further adjustments are needed. Folder Ad-115.
106 *Garlock Packing Co.

Packings, Asbestos Sheet......Features Klinger's compressed asbestos sheet packing . . . for every purpose. Makes available the Klinger Master Catalog which describes the complete range of products.
197 *Klinger Corp. of America

Packings, Teflon......Dura plastic teflon packing provides long uninterrupted sealing on all liquids except molten alkali metals and some florine compounds in the higher temperatures. Full details in Bulletin 461 CE.
B445 *Durametallic Corp.

Pulleys, Conveyor......Bulletin presents construction details, sizes and dimentions on Taper-Lock steel conveyor pulleys. Taper-Lock bushings are interchangeable in Dodge Taper-Lock conveyor pulleys. Bulletin D56.
313a *Dodge Mfg. Corp.

Rectifiers, Silicon......Brochure gives application notes on the 4JA60 series of small high current silicon rectifiers. Useful to designers of aircraft electronic equipment, automation equipment, etc. Bul. ECG-148A.
424D General Electric Co.

Sprockets......Taper-Lock double strand sprockets are available—ready for the shaft without re-machining. There is no flange, no collar, no protruding part. Flush design means safety. Details in Bulletin A-644.
312 *Dodge Mfg. Corp.

Starters, High Voltage......New ZHA Starter not only saves valuable floor space—it provides more accessibility and convenience than ever before. Available with self-contained bus in isolated compartment. Bulletin 8130-F.
207 *Electric Controller & Mfg. Co.

Timers......Bulletin describes the new Cramer Interval Timers, featuring high-torque motors and wide timing range, designed for commercial, industrial, process control, and laboratory use.
424E Cramer Controls Corp.

Turbines, Impulse......Bulletin covers: applications, pressure rises, typical arrangements, Volcan turbines, shop practices and methods, vertical impulse turbines and power recovery. Request Bulletin No. 147.
424F S. Morgan Smith Co.

*From advertisement, this issue

Handling & Packaging

Belts, V......New bulletin describes construction features of the "Texrope" grommet V-belt which provide 20 to 50% longer life than ordinary belts. Company makes Bulletin 20B6497C available upon request.
425A Allis-Chalmers Mfg. Co.

Bins, Bulk Material......Vertical or horizontal styles are available for any plant layout. To improve your plant's bulk storage and handling, company makes available valuable product Bulletins 529 and 549.
108f *Day Co.

Boxes, Pallet......New 8 p. catalog on Generalift standard industrial wirebound pallet boxes describes the many ways pallet box bulk handling can be applied and provide complete specifications.
425B General Box Co.

Cable......Cost-saving Armortube Cable is offered in a full family of sizes and types . . . aluminum or copper tubing . . . ¼, ⅜, ½-inch OD types. For more information and specifications, see Price List G91-9.
354 *Bailey Meter Co.

Chains, Roller......Dynamic strength assures longer work-life for Link-Belt roller chain. Complete range of single and multiple widths, ½ to 3-inch standard pitch, and 1 to 3-inch double pitch. Data Book 2457.
301 *Link-Belt Co.

Containers......"New and Better Containers" provides a picture-book tour of Continental's new building for metal container research and development in the packaging industry. Request your copy.
425C Continental Can Co.

Conveyors......Standard conveyor systems keep heavy, bulky commodities moving with minimum manpower and time loss. Systems can be job-tailored to any specific materials handling problem. Complete details in Bulletin 309.
422 *Standard Conveyor Co.

Conveyors, Screw......Link-Belt's sound engineering and quality manufacture assure you of top performance. A 92-page Screw Conveyor Book contains complete ordering data. Request your copy. Book No. 2289.
14 *Link-Belt Co.

Cranes, Jib......All cranes in the line have full 360° rotation and are self-supported on either base-mounted or pillar-mounted columns. Informative new folder gives illustrations and data on the full line.
425D R. G. LeTourneau, Inc.

Drums, Stainless Steel......Hackney removable head stainless steel drums protect shipment . . . open easily . . . close tightly. Available in several sizes. For information, request Hackney Drum and Barrel Catalog.
15 *Pressed Steel Tank Co.

Feeders.......Bulletin illustrates and gives specification data—capacities, accuracies, ranges, types of materials handled, etc.—on many types of feeders, lime slakers and proportioning pumps. Bul. 10-N1.
425E Omega Machine Co.

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LITERATURE . . .

Packaging......"1957 Guide to Improved Packaging" shows how Bakelite polyethylene, styrene, vinyl and phenolic plastics are creating new ways of getting products to customers with economy and speed.
426A Bakelite Co.

Rakes, Trash Rack......Leonard trash rack rakes reduce head and power losses at the intakes of hydro-electric plants, etc., by removing debris which gather on the racks and obstruct the water supply. Bul. No. 158
425B S. Morgan Smith Co.

Scales, Bagging......Product data sheet describes and illustrates new high-speed automatic fertilizer bagging scale, capable of bagging up to 24 sacks per minute. HA-39 fertilizer scale described in Data Sheet 5601.
426C Richardson Scale Co.

Scales, Bagging......Company offers information on new automatic belt-fed bagging scale which will weigh and bag up to fifteen 25- or 50-lbs., or twelve 100-lb. bags of grain and feed products a minute.
426D Richardson Scale Co.

Shovel-Cranes......New condensed catalog gives descriptive information on the more than 20 new models of Link-Belt Speeder shovel-cranes, all fully convertible to any standard front-end attachment. Book 2577.
426E Link-Belt Speeder Corp.

Tanks, Storage, Plastic......Haveg plastic tanks are economical to install... easy to maintain . . . durable. Require no painting or costly maintenance... can be readily field repaired where necessary. Bulletin C-13.
431a *Haveg Industries.

Trucks, Fork......Company announces Winter issue of the Lewis-Shepard Lever, a magazine prepared especially for fork truck users. Offers tips on buying various models of fork trucks. Request subscription.
426F Lewis-Shepard Products.

Trucks, Gas......Powerful Yale gas truck with new Yale hydraulic push-pull attachment stacks nitrate bags with maximum ease, safety and efficiency onto a pallet for shipping. Full facts available in Booklet 5101D.
299 *Yale & Towne Mfg. Co.

Trucks, Lift......The "Ohio" lift truck affords low-cost, one-man operation, picks up and releases automatically at proper height; is adjustable for load lifts ranging from 1,000 to 1,250 lbs. Catalog 56 F.
426G Portable Lift Trucks.

Unloaders, Pallet......The Alvey De-Palletizer is designed to receive pallet loads of cases and automatically unload each pallet onto a conveyor line. Bulletin F-225 describes unloader in detail.
426H Alvey Conveyor Mfg. Co.

Unloading......Wall chart gives instructions for the safe unloading and handling of sulphuric acid. Describes the proper methods for pump unloading and air unloading of tank cars —especially cold weather procedure.
426I Olin Mathieson Chem. Corp.

Weights, Digital, Remote.....New Toledo weight data systems feature: digital weights transmitted anywhere; automatic bulk weighing; product testing and sorting; dial location wherever you choose. Request booklets.
433 *Toledo Scale Co.

*From advertisement, this issue

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Heating & Cooling

Burners, Gas......Radiant tube gas burners feature: uniform heat distribution in tubes; flame length control; quieter operation; longer operation with less burner cleaning; etc. Request Data Sheet No. 808.
427A Hauck Mfg. Co.

Chillers, Scraped Surface......Adaptable to any process characterized by: heat transfer with crystallization, heat transfer with solvent extraction, heat transfer with high viscosity. Request Bulletin No. PE-2.
427B Henry Vogt Machine Co.

Coils, Plate.....Platecoil simplicity saves engineering, fabricating, installation, operation and maintenance costs in heat transfer. Units are compact and lightweight. Full details available in Bulletin P-61.
104 Tranter Mfg.

Components, High Temperature......Servo mechanism components are designed for reliability under high ambient temperature conditions encountered in numerous airborne and nuclear applications. Bulletin 410.
427C Norden-Ketay Corp.

Coolers, Liquid......Packaged liquid coolers include a complete refrigeration cycle, compressor, motor and starter, refrigerant controls, liquid cooler, condenser, piping, wiring and insulation, etc. Request catalog.
427D Doyle & Roth Mfg. Co.

Cooling Equipment......Company offers economy and reliability in cooling equipment for air conditioning, process work, ice making, quick freezing and other refrigerating purposes. Full details available in catalog.
342 *Frick Co.

Dehydrating Systems, Caustic......Swenson caustic dehydrating systems cost less to install, operate and maintain. They improve product quality and require less floor space. Full details available in Bulletin SW-203.
42-3d *Swenson Evaporator Co.

Evaporation......Brochure, "An Open Door" tells about unit operations such as evaporation, crystallization filtration, pulp washing & spray drying as a means to reduced costs & improved quality. Bul. SW-100.
42-3e *Swenson Evaporator Co.

Evaporators......"Evaporators For Recovery of Mercerizing Caustic" gives information on design, application, operation and construction of this type of evaporator. Details made available in Bulletin No. SW-201.
42-3b *Swenson Evaporator Co.

Evaporators, Phosphoric Acid......These evaporators feature: simple, compact design; time-proven, reliable; easy to operate; corrosion resistant; low maintenance; no fumes. Full details in Bulletin No. SW-202.
42-3c *Swenson Evaporator Co.

Furnaces......New bulletin covers modern, large size, field-erected production furnaces for all forms of metal heat treating, and also for continuous enameling, aluminum melting and ceramic requirements.
427E Lindberg Industrial Corp.

Furnaces, Industrial......New bulletin illustrates large variety of Surface standard equipment for all types of industrial heating applications, from small laboratory furnaces to large brazing furnaces. Bul.* SC-175.
427F Surface Combustion Corp.

Generators, Steam...... 16 p. book gives capacities, dimensions, construction features, instrumentation, accessories, sectional drawings & installation photos on new series of steam generators. Bulletin PG-55-3.
163 *Foster Wheeler Corp.

*From advertisement, this issue

LITERATURE . . .

Heat Exchangers......The Alcotwin heat exchanger furnishes real economy in first cost, in ease of installation and maintenance. Unlimited adaptability prevents obsolescence. Full details available in Bulletin FH-3.
17 *Alco Products.

Heat Exchangers......Aero heat exchanger cools liquids & gases by evaporative cooling with atmospheric air, removing the heat at the rate of input, controlling temperature precisely. Bulletins 120 & 124.
336 *Niagara Blower Co.

Heat Exchangers......Whitlock standardized heat exchangers save work, save engineering costs, save delivery time, save on repairs, save on first costs. Company makes complete details available in Bulletin No. 250.
356 *Whitlock Mfg. Co.

Heat Exchangers......Describes Type "SSF" stainless steel heat exchangers for heating or cooling liquids & gases as used in industries where elements of corrosion to alloys are encountered. Catalog No. 1155.
425 *Young Radiator Co.

Heat Exchangers, Acid Resistant...... Important data on Swenson type of tube mounting, types of corrosion resistant materials available and advantages of neoprene ring gaskets available in Bulletin SW-200.
42-3a *Swenson Evaporator Co.

Heat Exchangers, Shell & Tube...... Bulletin describes shell and tube heat exchange equipment. Outlines construction features, general specifications and standard materials for this equipment. Bulletin No. HE-1.
428A Heat Transfer Co.

Heat Transfer Systems......Capacities can range from small portable units to large gas- or oil-fired units generating from 250,000 to over 10,000,000 B.T.U.'s per hour. Request names of designers & manufacturers.
95b *Monsanto Chem. Co.

Heat Treating......New Bulletin explains the economic features of completely mechanized heat treat lines. It is a comprehensive commentary on mechanized heat treating. For full details, see Bulletin SC-176.
428B Surface Combustion Corp.

Heaters, Air......Versatile design permits Thermal Type CA heater to be used in a wide variety of installations and with either gas, oil or combination firing. Complete details available in Bulletin 104.
338 *Thermal Research & Engrg.

Heaters, Circulation......New 8 p. bulletin describes Chromalox automatic electric circulation heaters, for controlled heating of water, oils, heat transfer media, steam, air and other gases. Request Bulletin 701.
100 Edwin L. Wiegand Co.

Heaters, Liquid......Liquid heating systems feature: increased output; close, automatic temperature control; efficient, trouble-free operation; economical to install and operate; completely safe. Catalog 162.
428C S. Morgan Smith Co.

* From advertisement, this issue.

For the latest developments in **Chemicals Equipment Processes** you'll find our "Guide To Technical Literature" right up your alley. You can get any bulletin or catalog in this listing . . . and fast. Simply circle the item's number on the Reader Service Post Card and mail.

Heating Units, Immersion......Your fuel dollar buys more effective heat transfer with "Surface" immersion heating than with other methods of heating liquids and salts. Details Contained in Bulletin SC-156.
R450 *Surface Combustion Corp.

Ovens......Company offers illustrated bulletin describing laboratory and production ovens. Includes ratings, accessory information, features, diagrams applications and specifications. Bulletin No. 100.
T440 Despatch Oven Co.

Thermo-Panels......Cost less and perform better—an improvement on pipe coils. Save space and heat or cool more efficiently. For use in heating and cooling of liquids, slurries, etc. Request Bulletins 355 and 256.
TL459 *Dean Thermo-Panel Div.

Traps, Steam...... Give faster, more effective condensate removal. Powerful valves action, positive shut-off, high capacity & each unit service tested. For more details, request new Bulletin No. 10-55.
66 *W. H. Nicholson & Co.

Turbines, Steam......Turbines range from 150 horsepower down to fractional in 6 frame sizes. Feature large number of manually operated valves for individual control of steam nozzles. Details in Bulletin 135.
85 *Coppus Engrg. Corp.

Washers, Pulp......Pulp washers for the neutral sulphite semi-chemical pulping process. Advance design features will reduce pulp washing and evaporation costs. Full details available in Bulletin SW-300.
42-3f *Swenson Evaporator Co.

Instruments & Controls

Analyzers, Gas......Bulletin presents applications, calibration, design, performance and specifications (mass range, resolution, sensitivity, stability, response time, noise, construction, etc.). Bulletin 488.
429A Beckman Instruments.

Annunciator Systems......New 32 p. catalog describes the complete line of standard, integrated Panalarm Annunciator Systems for industry. Company makes full details available in Catalog No. 100B.
429B Panellit, Inc.

Control Elements, Static......New 8 p. bulletin defines static control, lists advantages, and describes components of General Electric's general-purpose static control system. Details in Bulletin GEA-6578.
429C General Electric Co.

Control Systems......16 p. booklet, illustrated with photographs, drawings, and circuit diagrams, discusses what Cypak is, how it works, and how Cypak elements process information. Details in Booklet B-6738.
429D Westinghouse Elec. Corp.

Control Systems, Batch......Catalog describes batch control systems. These systems offer simple, dependable means for automatically adding a predetermined volume of fluid to a batch process. Catalog 91-109.
429E Fischer & Porter Co.

Controllers, Temperature.....Series 53000 thermistor-actuated temperature controller is designed as an individual unit which is plugged into a separate power supply chassis. Details in Bulletin MC-133.
429F Fenwal Inc.

Controllers, Temperature......Brochure gives complete specifications on a new series of bulb-and-capillary indicating temperature controllers. Applications: rubber molding, process coolers, etc. Bul. MC-139.
429G Fenwal Inc.

* From advertisement, this issue.

LITERATURE . . .

Controls......New bulletin covers electrical remote positioning controls for both push button and automatic operation. Features new shaft mounted control gearmotor for valves and variable speed drives. Bulletin J-100.
430A Jordan Co.

Controls, Temperature......Features: cuts initial control costs; costly production stoppages; control maintenance costs. Controls for gas, liquids and solids in -30°F. to 1200°F. ranges. Condensed Catalog CC.
434 *Partlow Corp.

Controls, Temperature......Type E27A remote bulb temperature control contains two switches and, in many applications, may be used in place of two separate single-switch controls. Request additional information.
430B United Elec. Controls Co.

Controls, Temperature......Completely illustrated, 16 p. catalog presents company's line of standard local mounted temperature controls. Includes theory, features, general specifications, etc. Catalog Section 100.
430C United Elec. Controls Co.

Detectors, Leak......Leak detector features: simple to operate; uses safe inert helium as detecting agent; audible and visible leak indications; easy maintenance; sturdy, stable AC amplifier. See Bulletin 483.
430D Beckman Instruments.

Diffraction, X-Ray......Brochure discusses basic theory (Bragg's Law), definitions, analytical advantages and applications in metallurgy, chemistry, mineralogy, physiology, pathology, and biology. Pub. 7A-3690.
430E General Electric Co.

Fractometers, Vapor......16 p. brochure discusses the features and specifications of the new Model 154-B Vapor Fractometer. Also gives examples of trace analyses possible with it. Request your copy.
430F Perkin-Elmer Corp.

Gages......For pressure, vacuum or compound service. There are no gears or teeth to wear out. Cam wiping action keeps contact points clean and smooth. Complete information available in Catalog No. G-2.
321 *Helicoid Gage Div.

Gages, Liquid Level......Truscale remote reading liquid level gages are available as inclined gages for use where the gages have to be mounted high or low on the instrument panel, or at other points. See Bulletin 291.
430G Jerguson Gage & Valve Co.

Gages, Vacuum......Company offers new single-station, discharge-type vacuum gage which gives continuous pressure readings over an extended range from 25 microns to 1 x 10^{-7} mm Hg. Request Data Sheet No. 9-43.
430H Consolidated Electrodynamics.

Indicators, Stabilized pH......Offer these advantages: quick warm-up; fast response; measuring errors "designed out;" only two adjustments; fine performance. Company furnishes information in Data Sheet E-96(2).
132 *Leeds & Northrup.

Instruments......Company presents general catalog on instruments for analysis, control, and data processing. Covers: analog data-recording systems, recording oscillographs, galvanometers, etc. Bulletin 1305.
430I Consolidated Electrodynamics.

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Meters, Flow......New bulletin describes company's line of Series 18200 "Safeguard" Rotameters, versatile "variable area" type instruments for the accurate measurement of fluid rate-of-flow. Bulletin 18RG.
431A Schutte & Koerting Co.

Meters, Liquid......Neptune Print-O-Meter prints exact quantities, with serial numbers and code letters to identify the batch and/or station. Print-O-Meter sizes: 1 to 4 in., capacities 5 to 500 gpm. Bulletin 567-H.
427 *Neptune Meter Co.

Monitoring Systems, Temperature...... For dependable, close checking of many temperatures—company offers completely integrated, flexible system designed for exact monitoring needs. Full details in Bulletin 72-E.
350 *Thermo Electric Co.

Monitors, Moisture......New Type 26-301 Moisture Monitor gives accurate moisture measurement . . . down to one parc per million. Company makes complete information available in Bulletin No. CEC 1834-X1.
87 *Consolidated Electrodynamics.

Recorders, Oxidant......Bulletin covers description, operation and specifications (range, accuracy, air flow, liquid flow, recording, power consumption, size, weight, system time constant). Request your copy.
431B Beckman Instruments.

Recorders, Ratographic......Catalog is a complete, detailed report on the multiple applications, the many options available in F&P Ratographic instruments. Company makes details available in Catalog 55-20.
157 *Fischer & Porter Co.

Regulators, Temperature......Bulletin presents information on Spence temperature regulators. Includes piping layouts and helpful information on the installation of temperature regulators. Request Bulletin T150.
34 Spence Engrg. Co.

Regulators, Voltage......Bulletin covers Stabiline automatic voltage regulators . . . Type IE and Type EM. Rating chart simplifies selection of the regulator best suited to your need. Request Bulletin S 351.
431C Superior Electric Co.

Servo-Mechanisms......Company offers extensive experience with servo-mechanisms, controllers, aircraft systems, computer and memory devices, gyroscopes, telemetering equipment and digital systems. Facilities Report.
201 *Daystrom Systems Div.

Thermostats......Brochure describes two types of Fenwal Thermoswitch units which are encased in plastic for service in highly humid or corrosive environments. Company makes details available in Bulletin MC-137.
431D Fenwal Inc.

Varicells......Essentially, the components of a varicell are a powerstat variable transformer, a fixed-ratio rectifier transformer, a saturable core reactor, a rectifier stack and a ripple filter. See Bulletin SE 9551.
431E Superior Electric Co.

Pipe, Fittings, Valves

Couplings......New catalog describes Morflex couplings. Explains and illustrates the Morflex principle, employing preloaded rubber biscuits as the flexible medium. Specifications and dimensions in Cat. C41-56.
431F Morse Chain Co.

Couplings, Chain, Flexible......Revised catalog gives specifications, dimensions, ratings and application on series DSC, series SA silent chain couplings and series DRC roller chain couplings. Catalog C45-56.
431G Morse Chain Co.

* From advertisement, this issue

LITERATURE . . .

Fastenings . . . . . . 150,000,000 standard fastenings in brass, bronze, stainless, aluminum, copper, nickel and monel. Laboratory tests prove greater strength of Harper stainless steel machine bolts. Form 126.
326 *H. M. Harper Co.

Fittings . . . . . . "Aircraft Piping and Engineering Application Manual" presents data on fitting dimensions, installation and assembly methods, piping application categories, and engineering recommendations.
432A Weatherhead Co.

Fittings, Pipe . . . . . . Company offers a line of ductile cast iron pipe fittings, including "K" pipe lock couplings, screwed and flanged fittings, and companion flanges. Complete details available in Catalog No. 1.
432B Kuhns Brothers Co.

Flanges, Insert . . . . . . Sifco stainless insert flanges offer flexibility of installation, lower maintenance, fewer replacements. They eliminate the problem of bolthole alignment. Request full details and catalog.
L449 *Stainless Insert Flange Co.

Hose, Teflon, Flexible . . . . . . Heat-resistant, corrosion-proof, lightweight teflon flexible hose absorbs vibration, takes up movement, simplifies offset connections and installations in cramped spaces. Bulletin TF-100.
53 *American Metal Hose Div.

Hose & Tubing, Metal, Flexible . . . . . . New catalog simplifies selection and ordering of metal hose and tubing for industrial equipment and maintenance applications. Complete details available in Catalog G-560.
432C American Metal Hose Div.

Joints & Couplings . . . . . . Teflon expansion joints and flexible couplings absorb shock, vibration, thermal expansion and contraction. Connect unlike piping ends and nozzles. Full details available in Bulletin EJ-1155.
323 *U. S. Gasket Co.

Joints, Expansion . . . . . . Adsco expansion joints are more efficient than pipe bends for three reasons: less heat loss, less pressure drop, less space. In addition, these joints cost less. Bulletins 54-10PR and 35-51PR.
13 *American District Steam Div.

Joints, Expansion . . . . . . New 72 p. catalog covers the design, manufacture and application of the company's line of packless corrugated expansion joints, including three new types. Request Catalog #56.
285 Zallea Bros.

Nozzles . . . . . . Describes company's line of nozzles for: oil atomizing; humidifying; air washing; desuperheating; spray ponds; milk powdering; acid chambers; concrete curing; etc. Request Catalogs 6-A and 6-C.
L452 *Monarch Mfg. Wks.

Nozzles, Spray . . . . . . Company makes available on request a completely detailed Catalog which provides valuable data on Spraco Nozzle line. Includes information on full cone, flat spray & hollow cone types.
346 *Spray Engrg. Co.

Nozzles, Spray . . . . . . Company provides a 48 p. industrial catalog with full data on thousands of standard and special nozzles—for every type of spraying. Also information on related equipment. Catalog No. 24.
T455 *Spraying Systems Co.

Pipe & Fittings . . . . . . Luzerne PVC pipe and fittings are light in weight, easy to install with either screwed fittings or welding socket fittings, and economical. Immediate delivery. Details in Bulletin No. PF-1100.
L442 *Luzerne Rubber Co.

Pipe & Fittings, Jacketed . . . . . . Bulletin discusses standard jacketed fittings for maintaining uniform temperature (hot or cold), jacketed spring loaded plug valves, jacketed welded steel fittings, etc. See Bulletin J-57.
432D Hetherington & Berner.

* From advertisement, this issue

Pipe, Plastic......Ace Rivivor is a new rigid threaded plastic pipe with good aging and high impact strength. Not affected by most inorganic acids and alkalis. Company offers full details in Bulletin No. CE-56.
314c *American Hard Rubber Co.

Pipe, Plastic......General-purpose moderately priced rubber-plastic pipe handles most common chemicals to 170°F . . . except few strong acids & organic solvents. Tough, odorless, tasteless. Bulletin No. 80.
314a *American Hard Rubber Co.

Pipe, Rigid......Odorless, tasteless, rigid polyethylene has the best chemical resistance of any plastic at room temperature except to acetic acid. Rigid pipe ½" to 2". For complete details, Bulletin 351.
315b *American Hard Rubber Co.

Topworks......Super 70 Series Topworks give fast, accurate response. Four sizes are available in both direct and reverse acting types. Information on the new valve bodies of Super 70 Series line in Catalog 70-11.
81 *Black, Sivalls & Bryson.

Tubing, Flexible......Hundreds of applications in the steam and Diesel power fields are filled by Penflex flexible tubing. For complete information on product line, request copy of "Flexineering" booklet.
97 *Pa. Flexible Metallic Tubing.

Tubing, Plastic......Excellent chemical-resistant, all-purpose flexible plastic tubing. Sparkling clear, easy to clean, odorless, non-toxic, can be steam-sterilized. For details, request Bulletin No. 66.
314d *American Hard Rubber Co.

Tubing, Seamless......Catalog covers line of small seamless tubing and small tubular components. Details such Uniform specialties as pointer tubing and metal-shielded wire. Request your copy.
433A Uniform Tubes.

Unions, Forged Steel......Bulletin presents complete dimensional and engineering data on the complete line of W-S forged steel unions for high pressure service. Complete details available in Bulletin U-1-56.
433B Watson-Stillman Fittings Div.

Valves......Features: non-sticking; no metal-to-metal contact; needs no lubrication; requires no packing; renewable sleeve & plug. Details on type F valves are available. Request a copy of Bulletin V/4b.
293 *Duriron Co.

Valves......Four Powers Flowrite valve types are available to meet every requirement for accurate and dependable control. May be used with any pressure-operated sensing device. Full details in Bulletin No. 344.
R452 *Powers Regulator Co.

Valves......"Equa-Safe" valve mainifolds stop mercury blowing, damage to differential bellows & diaphragms. Entire story on what these valves can do for your differential instrument installations in Bulletin 56-1.
94 *Republic Flow Meters Co.

Valves......The Howell-Bunger Valve is an advanced design for the easy regulation and control of water under free discharge for high and low heads. Operates without excessive vibration or pitting. Bul. 156.
433C S. Morgan Smith Co.

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XUM

Valves, Cast Steel......Catalog describes all patterns, casting alloys, and seating combinations, with details of the extra value design and construction features of cast steel valves. Details available in Catalog.
289 *Jenkins Bros.

Valves, Check......Fast, quiet operation means low cost operation for check valves . . . and that's exactly what the Chapman Tilting Disc Check Valve is designed to do. Data on full line in Catalog No. 30-A.
134 *Chapman Valve Mfg. Co.

Valves, Check......Multi-purpose check valve outperforms—outwears other valves—costs less to maintain. Produced in numerous metals and alloys as well as polyvinyl chloride. Details available in Bulletin.
20 *Techno Corp.

Valves, Check & Foot......Bulletin describes corrosion resisting check and foot valves of Duriron and Durichlor. Corrosion resistance and mechanical characteristics of Duriron and Durichlor described. Bulletin V/10.
434A Duriron Co.

Valves, Control......Super 70 Series control valves offer: accurate response from topworks; greater stability through valve; self-actuating closure with float ring. Company makes details available in Catalog 70-11.
434B Black, Sivalls & Bryson.

Valves, Control, Diaphragm......Type 30 diaphragm control valve provides accurate pressure reduction and regulation of steam, water, air, oil, brine and most liquids and gases. Details in Bulletin No. 980.
434C A. W. Cash Co.

Valves, Diaphragm ...... Trouble-free plastic diaphragm valves—choice of general-purpose Ace-Ite, Ace Parian (polyethylene) or Ace Saran. Handles most corrosive chemicals & food ingriedents. Bulletins 80 & 351.
314b *American Hard Rubber Co.

Valves, Flow......New bulletin deals with eight types of Coppus Sentry full flow valves. Covers in detail the design, function, and specifications of these advanced valves. Full details available in Bulletin 500.
434D Coppus Engineering Corp.

Valves, Forged Steel......Two new rugged forged steel lines . . . 1300 line includes high flow port area, offering full-flow characteristics . . . 1100 line is compact and economical. Details in Forms 195 and 195-R.
111 *Ohio Injector Co.

Valve, Gate......Darling gate valves are made in metals, types and sizes for most services . . . and for pressures up to 1500 pounds. Feature fully revolving double disc parallel seat principle. Bulletin No. 5003.
320 *Darling Valve & Mfg. Co.

Valves, Gate & Needle......Bulletin graphically describes company's complete line of forged steel gate and needle valves, specifically designed for the petrochemical, power and process industries. Bul. DH-80.
434E American Chain & Cable Co.

Valves, Lubricated Plug......Catalog shows 100% pipe area, venturi, round port, and diamond port Homestead lubricated plug valves in a variety of metals for 150 lbs. steam working pressure. See Book 39, Section 5.
434F Homestead Valve Mfg. Co.

Valves, Polyvinyl Chloride......Chemtrol valves have excellent corrosion resistance, outstanding and constant flow characteristics, and immunity to electrolysis and galvanic action. Request Catalog No. C1056.
434G Chemtrol Corp.

Valves, Relief & Back Pressure......Makes available new line of relief valves and back pressure valves which can be used with corrosive fluid at pressures to 1500 psi and temperatures to 250 F. Bul. 1255-B.
434H Milton Roy Co.

* From advertisement, this issue

Valves, Safety Relief......Offer valuable features: economical "2 in 1" design; peak performance; absolute protection; maximum interchangeability. Full range of sizes and pressures available. Details in Catalog No. 1900.
40-1 *Manning, Maxwell & Moore.

Valves, Solenoid......Choose rugged industrial type Davis solenoid valves . . . for less downtime—less maintenance—more reliable control. For complete details of features, request copy of Bulletin 700.
L448 *Davis Regulator Co.

Process Equipment

Benders, Hydraulic......One man can easily carry and operate this hydraulic bender to quickly make uniform bends. Easily operated by hand or can be used with a power pump. Full details available in Bulletin No. D-217.
T441 *Greenlee Tool Co.

Centrifugals ...... Batch-Master offers choice of perforate and imperforate baskets . . . corrosion-resistant materials . . . manual unloader if desired. Further information available in Bulletin TC-14-56.
344 *Tolhurst Centrifugals.

Centrifugals......All components of the duty cycle are automatic and interlocked for accurate timing of successive operations; loading, discharging, and recycling are completely automatic. See Bulletin 5405.
341 *Western States Mach. Co.

Demineralizers......Company offers new dual column demineralizer with flow rate of 2500 GPH and fully automatic regeneration system. Further information on new ULA-2500 unit available on request.
435A Penfield Mfg. Co.

Dryers......Company offers three booklets with authoritative data on dryers: "The Moisture in Our Atmosphere," "Vapor Barriers for Dehumidification," "The Measurement of Water Vapor in Air." Request your copies.
79 *Pittsburgh Lectrodryer Co.

Dryers......Full line pressure reactivation, purging eliminated, longer absorpbent life, no moving parts, simple design, all air or gas entering dried without loss. Complete details in Bulletin 16.0.018.
333 *J. F. Pritchard & Co.

Dryers, Sprays......Bulletin tells how Swenson soluble coffee spray dryers are specifically designed for the production of "flavor-laden" soluble coffee. Company makes full details available in Bulletin SW-400.
42-3g *Swenson Evaporator Co.

Dust Collectors......AMERjet offers higher efficiency, lower service cost and smaller space requirements. For operations requiring complete dry dust recovery, and collection of the very finest particles. Bulletin 279.
56 American Air Filter Co.

* From advertisement, this issue

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LITERATURE . . .

Dust Collectors......Separating efficiencies of up to 98.9% on foundry shake-out dust are possible, practical and continuous with the Hydro-Filter. Turbulent area assures positive dust collection. Request Bulletin 55.
L450 *Dust Collector Corp.

Dust Collectors......New Self-cleaning collector offers continuous automatic operation, constant air volume and suction, uniform air flow resistance at low cost. For complete details, request Bulletin No. 915.
331 *Pangborn Corp.

Dust Collectors......In almost every type of industry . . . users have found high efficiency, simplicity & economy of Dustube collectors a difficult combination to equal for top performance. Request Bulletin No. 372C.
357 *Wheelabrator Corp.

Dust Collectors......Bulletin treats subject of super cleaning ordinary atmospheric air by means of specially adapted industrial cloth-filter-type dust collectors. Good for ventilation of laboratories. Bulletin 557-D.
436A Wheelabrator Corp.

Dust Collectors, Electric Precipitation......Design features which increase efficiency include large, clog-proof diameter, proper proportioning for maximum dust separation, extra-heavy gauge. Request specific data.
116 *Buell Engineering Co.

Dust Controllers......Complete, low cost unit combines high efficiency of Day Dual-Clone and Exhauster. Ideal for remote locations. Company makes full details available in Bulletin 510. Request your copy.
108e *Day Co.

Dust Filters......28 p. book explains in detail the distinguishing features of reverse jet filters. Contains schematic operating diagrams, performance curves for various types of dust. Request Bulletin No. 559.
108a *Day Co.

Dust Filters......"Type RJ" dust filter is an economical, high efficiency, automatic-continuous dust filter which can be furnished for pressure or vacuum operation. Full details available in Bulletin No. 560.
108c *Day Co.

Dust Separators......Exclusive Day design provides high efficiency with low horsepower requirements. For complete details on Dual-Clone dust separator, company makes available new product Bulletin 49DC.
108b *Day Co.

Filter Paper......The use of E&D filter paper as a cover may be indicated if your filter medium is blinding or clogging. Will recommend proper grade for use and send samples for testing. "Filtration Analysis Report."
348 *Eaton-Dikeman Co.

Filters, Automatic Water......Bulletin gives dimension charts for all three sizes of AWF Filters and for Poro-Stove, Poro-Screen and Poro-Edge elements. Includes installation photographs. Bulletin 909.
436B R. P. Adams Co.

Filters, Backwash......You can clean Adams filters by operating a few valves . . . no time consuming or dangerous manual disassembly and cleaning necessary. If you have a chemical filtration problem, see Bulletin 431.
107 *R. P. Adams Co.

Filters, Disc......Company's new 9' diameter filter has 105 sq. ft. in the filter area per disc. There are 12 segments per disc instead of the usual 10, giving greater filter capacity. May-June 1956 Deco Trefoil.
436C Denver Equipment Co.

Filters, Horizontal Plate . . . . . . New "Batch-Miser" horizontal plate filter recovers 100% of both liquid and solids—without scavenging. There is no leakage, no warping of plates. Request descriptive Bulletin.
345 *Niagara Filter Div.

* From advertisement this issue

Filters, Horizontal Rotary......"The Oliver Horizontal Rotary Filter" describes the outstanding features, design, operation, sizes and capacities of this continuous vacuum-type horizontal filter.
437A Dorr-Oliver.

Filters, Leaf......Line of pressure leaf filters and accessories can be adapted to an extremely diverse range of process conditions. For an immediate look at various types of process pressure leaf filters, request bulletins.
37 Process Filters.

Filters, Liquid......Company offers 12 pg. bulletin describing its Staynew filter. Contains engineering & performance data, photos, descriptions of filtering media, recommended use of each, etc. Request Bulletin 300.
90 *Dollinger Corp.

Filters-Mixers-Tanks......Alsop filters, mixers, and tanks are available in a complete range of sizes and capacities, and the equipment is custom fitted to your application. Full details in new complete catalog.
R449 *Alsop Engrg. Corp.

Filters, Vertical Pressure......Bulletins provide details on Cochrane vertical pressure filters with positive foolproof filter control, for use in industrial plants, hospitals, etc. See Publications 6319 and 6320.
437B Cochrane Corp.

Filters, Vacuum, Rotary, Continuous......*The Original String Discharge* Filter is only one of many types of FEinc continuous rotary vacuum filters available . . . custom-made at standard costs. Request Bulletins.
131 *Filtration Engineers.

Filtration Equipment......Sperry makes available a catalog complete with charts, tables, & diagrams to help in the operation, maintenance & selection of filtration equipment. Request your copy. Catalog 7-E.
R457 *D. R. Sperry & Co.

Fume Systems, Plastic......Haveg fume removal units are light in weight for easy, low cost installation, or for heavy duty service where required. Haveg is tough, durable, machineable, easily repaired. Bulletin F-7.
431b *Haveg Industries.

Generators, Inert Gas......Assure a safe, dependable supply of chemically clean inerts. Deliver inerts at a special analysis . . . without fluctuations. For facts and technical data, request Bulletin No. 1-10.
119 *C. M. Kemp Mfg. Co.

Grinding Machines ...... Sturtevant Micronizer grinding machines give greater finenesses than tube or roller mills. Feature: no moving parts; instant accessibility; easy cleaning. For details, see Micronizer Bulletin.
213 *Sturtevant Mill Co.

Lubrication Systems......Accumatic advantages: prevents application of wrong lubricant; seals completely against damaging dirt; no parts are neglected; eliminates point-by-point lubrication methods. Catalog.
71 *Stewart-Warner Corp.

Mills, Attrition, Single Run......Versatile size reduction unit rubs, cuts, tears, crushes, grinds, granulates, pulverizes, twists, curls, hulls, and blends. Company makes details available in Bulletin No. 143.
77a *Sprout-Waldron.

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LITERATURE . . .

Mills, Ball......Traylor grinding mills are offered in a wide variety of types including: ball, rod, compartment and tube mills for wet or dry . . . coarse or fine grinding. Full details in Bulletin 11-121.
19 *Traylor Engrg. & Mfg. Co.

Mills, Colloid......New two-stage colloid mill features a special RE design, incorporating removable rotor, stator and rotary shaft seal. Said to simplify operating, speed changeover and cleaning. Request your copy.
438A Manton-Gaulin Mfg. Co.

Mills, Disc-Roll......Hardinge Disc-Roll Mill is a roller-type mill with two adjustable, pneumatically loaded rolls for grinding material on a horizontal rotating disc or table (Loesche type). See Bulletin 52-11.
430 *Hardinge Co.

Mills, Grinding......Catalog discusses proper application and selection of conical mills, tricone mills, cascade mills, rod mills, tube mills and disc roll mills for dry grinding problems. See Bulletin 17-C.
438B Hardinge Co.

Mills, Laboratory......Bulletin presents all information necessary to determine from six standard models offered, the most suitable mill for any individual requirement. Includes illustrations and drawings. Bul. 203.
438C Farrel-Birmingham Co.

Mills, Pellet......"Junior" Model 500-B Pellet Ace has already proved itself in the processing field and will produce highest quality pellets on a production basis. Specifications and drawings in Bulletin 165.
438D Sprout, Waldron & Co.

Mills, Roller......Company offers Raymond Roller Mill with double Whizzer Separator. Suited for large capacities. Flash drying accessories may be furnished with the mill. Full details available in Catalog 79.
232 *Raymond Div.

Mixers......Day Jumbo Mixers meet every requirement imposed by heavy loads. Equipped with two roller bearings mounted on heavy fabricated supports. Available in 600- to 3850-gallon capacities. Details in Bulletin 800.
325 *J. H. Day Co.

Mixers......Bulletin outlines how the Simpson Mix-Muller is used in the preparation of electronic porcelain, tile, structural clay and brick, refractories and other ceramic bodies. See Bulletin 452A-5M-7.56.
438E Simpson Mix-Muller Div.

Mixers, Batch......Gruendler line of tilting batch mixers is ruggedly constructed to efficiently handle a wide variety of materials and capacities. Available in many sizes and interior finishes. See Bulletin B-12.
438F Gruendler Crusher & Pulverizer.

Mixers, Ribbon......New bulletin describes eight different sizes of ribbon type mixers, available with choise of six different agitator types. Working capacities ranging from 25 to 450 gallons. See Bulletin No. 300.
438G Cincinnati Hildebrand Co.

Mixers, Slurry......Bulletin describes the design variations, sizes, physical characteristics, capacities, special features and operation of Dorr slurry mixers. Includes drawings and photographs. Bulletin 1141-R.
438H Dorr-Oliver.

Plastic Equipment, Corrosion-Resistant......New 32 p. catalog covers company's corrosion-resistant plastic equipment. Gives complete coverage to Haveg's wide range of synthetic resin formulations. See Catalog C-14.
438I Haveg Industries.

Presses, Filter......Offer numerous features: lowest cost per sq. ft. of filtering area; produces perfect clarity of filtrate; can be used in decolorizing—deodorizing; etc. "Guide to Better Filtration."
423a *T. Shriver & Co.

* From advertisement this issue

Presses, Industrial Compacting......New catalog describes complete line of Stokes industrial compacting presses, used for making a wide variety of products, from tiny ferrite rings to large ceramic parts. Catalog 816.
439A F. J. Stokes Corp.

Process Equipment......Company has a team of specialists that consider unusual fabricating requirements. There is no problem with rigid customer specifications. Complete details made available in Facilities Booklet.
287 *Chicago Steel Tank Co.

Process Equipment......Large scale and special purpose process equipment for the chemical, textile, plastic, rubber and allied industries is described in new brochure. Design and construction details given. Bulletin 236.
128 Dravo Corp.

Process Equipment......Company will assist you in determining the most efficient equipment for conveying, cooling, and preheating dry materials; feeding and aeration in bulk materials, etc. Full details in Bulletin G-3.
96 *Fuller Co.

Process Equipment......Bulletin covers continuous granular fertilizer processing equipment such as: ammoniators, granulators, dryer furnaces, dryers, coolers, combination dryers and coolers, air handling systems.
439B Edw. Renneburg & Sons Co.

Processing Equipment......Describes corrosion-resistant processing equipment . . . precision built to your specific requirements to give long years of peak performance with low maintenance. Technical Bulletins.
319 *Lee Metal Products Co.

Processing Equipment, Impervious Graphite . . . . . . Bulletin shows a typical drawing or illustration of each type of equipment, lists the standard models available. Company makes details available in Bulletin No. 249.
417 *Falls Industries.

Propellers, Fabricated......"Fabricated" propellers will do a perfect job of mixing, blending, stirring, pumping or aerating in applications requiring relatively low horsepower and not over 1750 LPM. Request catalog.
B444 *Michigan Wheel Co.

Pulverizer-Classifier......The Pulvocron is an air attrition impact pulverizer and classifier with controlled radial inward air classification. Makes possible precision grinding and classifying in one operation. Bulletin.
187 Strong Scott Mfg. Co.

Reclaimer Systems, Oil......A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. Offers full details on reclaimers in Bulletin R-160.
328 *Hilliard Corp.

Rectifiers, Mercury Arc......New bulletin describes mercury arc rectifiers which provide reliable, low cost power conversion in steel mills, chemical plants, transportation systems, etc. Bulletin 12B8494.
439C Allis-Chalmers Mfg. Co.

Rolling Machines, Jar......Multiple batches of similar or different materials can be economically ground, pulverized or mixed simultaneously on a versatile Abbe jar rolling machine. Full details in Catalog No. 79.
426 *Abbe Engineering Co.

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Screens, Vibrating......New bulletin describes construction features of vibrating screens for handling feed up to 6 and 20 inches and coal up to 8 and 24 inches. Full details made available in Bulletin 07B6151D.
440A Allis-Chalmers Mfg. Co.

Softeners......Bulletin covers Cochrane Hot Lime-Zeolite softeners—method of operation, expected results, chemical savings and simplicity of operation. Company makes full details available in Publication 4801-A.
440B Cochrane Corp.

Trays, Ripple......**High capacity and** simplicity of construction of ripple trays have effected major savings in first cost over conventional bubble cap trays. Complete details made available in illustrated booklet.
69 Stone & Webster Engrg. Corp.

Wire Cloth......80 p. catalog describes company's facilities for fabricating wire cloth parts. Wire cloth parts for screening, filtering and special uses. Provides useful metallurgical data. Request your copy.
421 *Cambridge Wire Cloth Co.

Pumps, Blowers, Compressors

Compressors ...... Describes Allis-Chalmers single and two-stage vane type compressors for shop air, gas handling, drilling and numerous other applications. Request Bulletin Nos. 16B8244 and 16B8126.
91 *Allis-Chalmers Mfg. Co.

Compressors......Hofer compressors feature: horizontal multistage construction with only one stuffing box; metal packing; sight bubble indicator forewarns time for packing adjustment; noiseless operation. Catalog.
72 *Autoclave Engineers

Compressors......New, 16 p. bulletin shows complete line of small, air-cooled compressors for industrial, automotive, commercial and general use. Offers both one- and two-stage compressors. Bulletin AC-15.
440C Gardner-Denver Co.

Compressors, Centrifugal......De Laval compressors are designed and built for heavy duty continuous operation. Rugged, horizontally split casings . . . individually designed impellers . . . etc. See Bulletin 0504.
222 *De Laval Steam Turbine Co.

Fans......New brochure describes Chicago Blower's entire line of Axial Airfoil fans. Pictures eight distinct fans with dimensional charts, performance tables, certified ratings and operational descriptions. Bul. AA-102.
440D Chicago Blower Corp.

Fans....Marley multi-blade cast fans are inherently rugged and durable. Never develop tip-sag or service flutter. Design eliminates weld and rivet failures, skin cracks and imperfect laminations. Bulletin FH356.
9 *Marley Co.

Fans, Centrifugal......40 p. booklet features new listing of quiet operating, large capacity, slow speed centrifugal fans. Presents detailed performance charts. Details in Bulletin C-103, Supplement No. 1.
440E Chicago Blower Corp.

Fans, Exhaust......High air delivery per horsepower required. Statically and dynamically balanced; designed exclusively for dust control applications. Company makes complete details available in Bulletin 471.
108d *Day Co.

Pumps ...... Available in aluminum bronze, stainless steel, Hastelloy and titanium, Aldrich fluid ends handle all types of liquids—nitric acid, caustic solutions, fatty acids, etc. Full details in Data Sheet 100.
68 *Aldrich Pump Co.

* From advertisement this issue

Pumps......Bulletin details the distinctive characteristics, materials of construction, types, sizes and capacities of the six major types of Dorr-Oliver pumps for the chemical process industry. Bulletin 5000.
441A Dorr-Oliver.

Pumps......Company offers two types of pumps for volume pumping and for great pressure . . . single-stage pump and double stage pump. See Bulletin 721.6 for single-stage pumps, Bulletin 722.6 for double-stage pumps.
429 *Goulds Pumps.

Pumps......Company offers engineered, dependable performance complete from water location to year after year of trouble-free pumping. Your pump is created for your job. Complete details in Bulletin No. 100.
57 Layne & Bowler

Pumps......Handle most anything that can pass through a pipe, from free-flowing liquids to non-pourable pastes —materials containing relatively large particles or abrasives. Details in Bulletin 30-CE.
59 *Robbins & Myers.

Pumps......Offers new bulletin on sanitary liquid end controlled volume pumps. Describes the construction of the sanitary liquid end and the ease with which it is disassembled for cleaning. Bulletin 1056.
441B Milton Roy Co.

Pumps......Practical Guide to Pump Selection—illustrations & descriptions with capacities & adaptability of pumps contained in compilation of facts to help avoid costly misapplication. Bulletin No. S-146.
R442 *Taber Pump Co.

Pumps......If you have a problem where metering, blending or other accurate pumping of liquids is concerned, let Viking help solve it. Use Viking pumps for accurate pumping. For information, request Bulletin 57Sc.
B455 *Viking Pump Co.

Pumps, Acid......80-gpm. centrifugal pump with hard rubber casing and impeller, Hastelloy C shaft. Handles nearly all corrosives. Mechanically simple, trouble-free. For information, request Bulletin CE-55.
315d *American Hard Rubber Co.

Pumps, Acid......Bulletin describes the design features, corrosion-resistant materials of construction, applications, sizes and capacities of the Olivite acid handling pump. Full details in Bulletin No. 5004.
441C Dorr-Oliver

Pumps, Acid & Chemical......Pumps to handle every acid or chemical fluid used in industry. Offers help with particularly difficult chemical pumping problems. For pertinent details, request Bulletin 203-7.
347 *Lawrence Pumps.

Pumps, Centrifugal......The Eastern D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Complete specifications on all Eastern centrifugal pumps in Bulletin 120-B.
353 *Eastern Industries.

Pumps, Centrifugal......Illustrated reference describes line of SSV centrifugal pumps. Includes details of construction of the various sizes available, operating advantages for users, etc. Bulletin No. 107.
R446 *Frederick Iron & Steel.

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LITERATURE . . .

Pumps, General Purpose......Designed for a broad range of clean liquid applications, these Roper Series 3600 Pumps are recognized for highly dependable performance, low maintenance characteristics. Catalog.
340 *Geo. D. Roper Corp.

Pumps, High Pressure......Catalog describes company's Series HP Pumps. They meet an entirely new conception of operating requirements—demanded by modern high pressure processing techniques. See Catalog HP-1254.
317 *Philadelphia Pump & Machy.

Pumps, High Vacuum......Catalog covers: industrial and scientific applications, types of vacuum systems, operating mechanism, vibration elimination, gas ballast, discharge valves, etc. Request Catalog 425.
442A Kinney Mfg. Div.

Pumps, Porportioning......Design features which contribute to the exceptional feeding accuracy, positive feed rate setting, and initial and operating economies of new model Proportioneer described in Bulletin 1140.
442B Proportioneers, Inc.

Pumps, Rotary Liquid......Bulletin covers: vacuum pumps, pumping information, strainers, heliquad pumps, pump drives, rotating plunger pumps, history, representative types, etc. Details in Bulletin L51A.
442C Kinney Mfg. Div.

Pumps, Sewage......Offer heavy duty construction, close tolerance doweling fittings from motor base through to pump casing, and positive alignment of all rotating and guide-bearing parts. Request Bulletin 7500.
322 *Denning Co.

Pumps, Vacuum......Beach-Russ vacuum pumps give: fast "pump-down;" high efficiencies; quiet, vibrationless operaiton; long service life. Available in a complete range of types and sizes. See Bulletin 89.
351 *Beach-Russ Co.

Pumps, Vacuum......Stokes Vacuum Calculator simplifies calculation of pump performance and selection of pump size for specific applications. Full story on Microvac design features in Catalog No. 752.
78 *F. J. Stokes Corp.

Ventilators, Roof......Three, new, "low silhouette" sizes have been added to the Ilg roof ventilation line. Models range in height from 6⅝ to 12⅝ inches. Capacities range from 287 to 938 cfm. Bulletin 2300.
442D Ilg Electric Ventilating Co.

Services, Processes, Misc.

Cut-Machining Units......44 p. book explains briefly the various types of abrasive cut-off saws . . . portable combination cut-off and deburring chop saw, swing type cut-off saw and rotating cut-off saw.
442E Wallace Supplies Mfg. Co.

Extinguishers, Fire......Company offers these types: foam soda-acid clear water anti-freeze; cartridge-operated dry chemical; pressurized dry chemical; squeeze-valve carbon dioxide; trigger carbon dioxide. Bul. P-8.
416 *Walter Kidde & Co.

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Gloves, Industrial......New catalog describes Wilson's complete line of curved-finger rubber, latex, neoprene, Buna-N, and compar plastic gloves. Includes a chart of finger cot sizes in actual diameters.
443A — Wilson Rubber Co.

Grating & Stair Treads......Blaw-Knox electroforged steel grating makes every step a safe step indoors or outdoors. Makes available new reference & quotations. For more information request Bulletin 2486.
102 — *Blaw-Knox Co.

Laboratory Equipment & Furniture...... Company makes available a catalog describing its line of top-quality tables, cases, cabinets, fume hoods & radio chemical lab equipment. For details, request Catalog.
T443 — *Duralab Equipment Corp.

Laboratory Equipment & Furniture...... Line of sectional units designed for interchangeability & flexibility assures a synchronized installation which will produce peak efficiency. 180 p. Catalob 4B & Supplement 55-A.
B440 — *Metalab Equipment Corp.

Laboratory Ware......Offers many properties important to development, experimental or analytical work. It is chemically stable, stands temperatures to 1900° C. and is easy to clean. Complete data in Bulletin 793.
443B — Norton Co.

Models, Industrial......Bulletin covers: cost of a model; delivery; model quality; available scales; how to reproduce model arrangement on blueprints; how to get a model estimate; colors. Request your copy.
443C — Industrial Models

Plant Sites......Data on raw materials, transportation, power and fuel, markets, labor, facilities, sites, community services, laws and regulations, etc. Also includes physical map. "Industrial Location Services."
R448 — *N. Y. State Dept. of Com.

Polyethylene Ware......Bulletin contains descriptive material and photographs of a wide variety of polyethylene ware for general laboratory use. Describes such items as: funnels, siphons, bottles, etc. Bulletin 35.
443D — Central Scientific Co.

Research......Bulletin covers facilities involving electrical, mechanical, physics, nuclear, chemical, metallurgical, and processing research projects. Company makes full details available in Bulletin 48B8448.
443E — Allis-Chalmers Mfg. Co.

Research........New bulletin describes Fluor Research facilities which are now available to industry on a contract basis. Explains services offered by the staff and gives case histories of recent projects.
443F — Fluor Corp.

Research & Development......"How to Develop Successful New Products" presents up-to-the-minute facts about competitive features, potential place in the market, production techniques and material costs.
58 — Foster D. Snell, Inc.

Safeguards, Combustion......Bulletin describes the operation and construction of Selas automatic fire checks and Selas safety blowouts. Also presents principles of operation and installation data. Bulletin SC-1006.
443G — Selas Corp. of America

Splices......New 4 p. illustrated booklet contains instructions & application information for the new "Scotchcast" brand splicing kit 90-B1. Describes advantages, electrical & physical properties, etc.
443H — Minnesota Mining & Mfg. Co.

Waste & Sewage Treatment......Two new booklets report latest results in water, waste and sewage treatment entailing the use of Separan 2610, Dow's new high speed flocculating agent. Available upon request.
443I — Dow Chemical Co.

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